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Ferrocyanide Safety Program Rationale for Removing Six Tanks From the Safety Watch List

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ABSTRACT

This report compiles information from a variety of sources to provide a technical basis for removing tanks 241-BX-102, -106, -110, -111, 241-BY-101, and 241-T-101 from the Ferrocyanide Watch List. Included are detailed descriptions of waste transfer operations, and waste transfer data for the period tanks were in service. Also included is information considered by the Department of Energy for authorization to stabilize tank 241-T-101.

Some of the tanks received "sidepocketed" supernatant because of high ^{60}Co or ^{90}Sr concentration. The soluble ferrocyanide content of the settled supernatant was very low, and it is important to note that ferrocyanide ion was not added in excess of nickel ion during scavenging. A thorough review of the available ferrocyanide scavenging records concluded that tank 241-T-101 (because it was refilled with metal waste and sluiced again in 1956 after receiving ferrocyanide sludge in 1953); tanks 241-BX-102, -106, and 241-BY-101 (because these tanks received only ferrocyanide scavenging supernatant); and tanks 241-BX-110 and -111 (because these tanks did not receive any ferrocyanide waste, sludge or supernatant) do not contain the requisite 1000 g-moles or more of ferrocyanide. Therefore, these six tanks do not belong on the Ferrocyanide Watch List.

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SECTION 1.0

INTRODUCTION

1.1 PURPOSE

This report provides an organized technical basis for removing Hanford Site waste tanks 241-BX-102, -106, -110, -111, 241-BY-101, and 241-T-101 from the Ferrocyanide Watch List.

1.2 HOW TO USE THIS DOCUMENT

Material from a variety of sources has been compiled to form this report, including excerpts from several documents, Westinghouse Hanford Company internal memos, meeting minutes, and letters. Information that supports removing tanks 241-BX-102, -106, -110, -111, 241-BY-101, and 241-T-101 from the Ferrocyanide Watch List has been incorporated into this report. Section 2.0 describes waste transfer operations in the tanks and explains why the six tanks contain less than 1000 g-moles of ferrocyanide. Section 3.0 provides waste transfer data while the tanks were in service. Section 4.0 contains the information considered for the Department of Energy's authorization to stabilize (pump) tank 241-T-101.

1.3 BACKGROUND

Radioactive wastes from defense operations have accumulated at the Hanford Site in underground waste tanks since the early 1940s. During the 1950s, additional tank storage space was required to support the Hanford Site defense mission. To obtain this additional storage volume in a short period of time, and while minimizing the construction of additional storage tanks, Hanford Site scientists developed a process to scavenge radiocesium and other soluble radionuclides from tank waste liquids. As a result of implementing this process, approximately 140 metric tons of ferrocyanide were added to a number of single-shell tanks (SSTs).

Ferrocyanide is a complex of ferrous ion and cyanide that is considered nontoxic because it is stable in aqueous solutions. However, in the presence of oxidizing materials, such as nitrates and nitrites, near-stoichiometric amounts of ferrocyanide can explode under special conditions in the laboratory by (1) heating it to high temperatures (above 285 °C); or (2) by an electrical spark of sufficient energy to heat the mixture. The explosive nature of ferrocyanide in the presence of an oxidizer has been known for decades, but the conditions under which the compound can undergo an exothermic reaction have not been thoroughly studied. Because the scavenging process involved precipitating ferrocyanide from solutions containing nitrate and nitrite, it is likely that an intimate mixture of ferrocyanides with nitrates and nitrites exists in parts of some of the SSTs.

Efforts have been underway since the mid-1980s to evaluate the potential for a ferrocyanide reaction in the Hanford Site single-shell tanks (Burger 1989, Burger and Scheele 1988). In 1987, the final environmental impact statement for disposal of Hanford Site waste farms was issued (DOE 1987). The environmental impact statement projected that the bounding "worst-case" accident in a ferrocyanide tank would be an exothermic reaction resulting in a subsequent short-term radiation dose to the public of approximately 200 mrem.

A General Accounting Office study (Peach 1990) postulated a "worst-case" accident, with independently-calculated doses greater than the 1987 DOE environmental impact statement. A special Hanford Site Ferrocyanide Task Team was commissioned in September 1990 to address all issues involving the ferrocyanide tanks, including the consequences of a potential accident. On October 9, 1990, then Secretary of Energy James D. Watkins announced that a supplemental environmental impact statement would be prepared that contained an updated analysis of safety questions for the Hanford Site single-shell tanks (including analysis of a ferrocyanide explosion) (DOE 1990).

Using process knowledge and historical records, 24[1] tanks were identified at the Hanford Site that contain 1,000 g-moles or more of ferrocyanide as the $Fe(CN)_6^{4-}$ radical. In October 1990, the ferrocyanide issue was declared an Unreviewed Safety Question[2] because the safety envelope for these tanks may no longer be bounded by the existing safety analysis report (Bergmann 1986) and the 1987 DOE environmental impact statement. Work in and around any of the ferrocyanide tanks requires detailed planning, together with the preparation of supporting safety and environmental documentation, and approval by DOE management. These restrictions are safety requirements and significantly increase the time required to complete work or install equipment in the tanks.

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[1]Two more tanks that potentially contain ferrocyanide were identified since the DOE responded to Recommendation 90-7 (FR 1990) in November 1990.

[2]An explanation of an Unreviewed Safety Question, as defined by DOE Orders 5480.5 (DOE 1986) and 5480.21 (DOE 1991), follows. "A proposed change, test or experiment shall be deemed to involve an Unreviewed Safety Question if:

- The probability of occurrence or the consequences of an accident or malfunction of equipment important to safety, evaluated previously by safety analysis will be significantly increased, or

- A possibility for an accident or malfunction of a different type than any evaluated previously by safety analysis will be created which could result in significant safety consequences."

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SECTION 2.0

BASIS FOR THE REMOVAL OF TANKS

241-BX-102
241-BX-106
241-BX-110
241-BX-111
241-BY-101
241-T-101

FROM THE FERROCYANIDE WATCH LIST

2.1 DEVELOPMENT OF THE FERROCYANIDE TANK LIST

A list of Hanford Site waste storage tanks that contain ferrocyanide was first developed in 1984 as input to a report on ferrocyanide stability (Burger 1984). This list (Pickett 1984) identified 14 ferrocyanide tanks:

241-BY-104, -105, -106, -107, -108, -110, -112
241-C-108, -109, -111, -112
241-T-101,
241-TY-101, -103.

The ferrocyanide stability document, released subsequently as PNL-5441, included this listing and also mentioned tanks 241-C-101, 241-TY-104, -105 and -106.

The list was expanded in March 1989, when an internal memo on "Data Analysis of Conditions in Single-Shell Tanks Suspected of Containing Ferrocyanide" was written (Nguyen 1989). This memo used Track Radioactive Components (TRAC) (Jungfleisch 1984) to identify tanks containing ≥ 1000 g-moles of ferrocyanide and this expanded the list to include 22 tanks. The list contained the following tanks in addition to the original 14:

241-BX-102, -106, -110, -111
241-BY-101, -103, -111
241-TX-118.

These 22 tanks comprised the list of ferrocyanide tanks identified when the Ferrocyanide Unreviewed Safety Question (USQ) was declared at the Hanford Site.

In January 1991, a review of Hanford Site monthly reports for ferrocyanide data found that approximately one half of the original ferrocyanide inventory in tank 241-T-101 was transferred to tank 241-T-107 in late 1953/early 1954. Also at this time, the records for disposal of ferrocyanide waste to ground (Ruppert and Heid 1954) were reviewed and it was concluded that tank 241-TY-104 may have directly received scavenged waste from T Plant. Subsequently, tanks 241-T-107 and 241-TY-104 were added to the ferrocyanide list via an Occurrence Report (Borsheim and Cash 1991).

A 1991 study (Borsheim and Simpson 1991) reviewed the available ferrocyanide scavenging records thoroughly. This study concluded that tank 241-T-101 (because it was refilled with metal waste and sluiced again in 1956 after receiving ferrocyanide sludge in 1953); tanks 241-BX-102, -106, and 241-BY-101 (because these tanks received only ferrocyanide scavenging supernatant); and tanks 241-BX-110 and -111 (because these tanks did not receive any ferrocyanide waste, sludge or supernatant) do not contain the requisite 1000 g-moles or more of ferrocyanide.

The document published as a result of this study provided a comprehensive assessment of the ferrocyanide tank inventories through the end of the scavenging program which involved the following steps:

1. Historical (ca. 1954-1955) process development and flowsheet bases documents[3] were retrieved and reviewed to determine the feed stream constituents, reactant [$Fe(CN)_6^{-4}$ and Ni^{+2}] concentrations, and volume percent resultant precipitate.

2. Historical operating documents were retrieved and reviewed to confirm constituent/reactant concentrations, determine batch input/output volumes, and assess the available ferrocyanide sludge inventories.

3. A spreadsheet model was developed to calculate the tank cumulative ferrocyanide sludge, ^{137}Cs, and ^{90}Sr inventories as a function of input/output volumes. A value of 4.25 volume percent ferrocyanide solids (i.e., 10,000 gal of solution would yield 425 gal of sludge) was used for the model. This value was based upon flowsheet documents, operating records, and sensitivity studies.

4. The ferrocyanide settling/collection tanks were equipped with floating suction pumps and gamma-monitored discharge lines to minimize the inadvertent transfer of ferrocyanide solids out of the tanks to the ground or to other tanks. The supernatant from the collection tanks was tracked (via transfer records) from input to the tanks to discharge to the ground.

5. Post-scavenging program (after 1958) transfers from the settling/collection tanks were reviewed to determine if such transfers were large enough to have disturbed the ferrocyanide sludge.

Scavenging supernatant would not have contained appreciable insoluble or soluble ferrocyanide. A review of the historical flowsheets and operating records indicated that, although the ferrocyanide and nickel ion added greatly exceeded the required amount to precipitate the fission product cesium as $Cs_2NiFe(CN)_6$ or $CsNaNiFe(CN)_6$, the ferrocyanide ion was not added in excess of the nickel ion. Therefore, precipitation of essentially all of the ferrocyanide as a nickel ferrocyanide (predominately $Na_2NiFe(CN)_6$) was expected. Although analyses of the actual scavenged supernatant for ferrocyanide or cyanide have not been located, some of the supernatants from recent ferrocyanide flowsheet simulations were analyzed. Jeppson and Wong (1993) reports a cyanide analysis for the supernatant from one flowsheet simulant as 0.000319 M, which corresponds to two percent of the added ferrocyanide remaining soluble. It was reported in Bechtold and Jurgensmeier (1992) that "virtually all of the cyanide and nickel do precipitate." The reported percentages of cyanide remaining in the supernatant from these flowsheet tests ranged from 0.1 to 5.5 %. While the 5.5 % seems atypically high, it can be shown that even at this value, tanks 241-BX-102, -106, and 241-BY-101, which received the supernatant from U Plant scavenging (maximum ferrocyanide concentration of 0.005 M), would contain less than 1000 g-moles of ferrocyanide.

[3]These documents are referenced in Borsheim and Simpson (1991).

The operating records for the scavenging program are quite good for input/output volumes, although sludge level measurements are spotty. The 4.25 volume percent solids value has been confirmed by recent flowsheet simulant laboratory studies (Jeppson and Wong 1993) for the U Plant scavenging process (the six tanks considered in this section are concerned only with transfers from tanks that contained U Plant scavenging flowsheet material). There is the possibility that large, unrecorded transfers from the settling/collection tanks could have moved ferrocyanide solids to other tanks. However, the tank volumes were inventoried periodically (to monitor for leakage) and no inventory discrepancies are apparent. The Borsheim and Simpson report did not consider the possible effects of sludge compaction or aging; nor did it consider the possible reaction of the ferrocyanide sludge with wastes added to the tanks at a later date. These events would not increase the estimated tank inventory. Instead, they would decrease it through ferrocyanide destruction or solubilization.

2.2 SPECIFIC HISTORIES FOR THE SIX SELECTED FERROCYANIDE TANKS

2.2.1 Tanks 241-BX-102 and 241-BX-106

Tanks 241-BX-102 and -106 are on the Ferrocyanide Watch List because the TRAC report (Jungfleisch 1984) listed them as having a 1000 g-moles ferrocyanide inventory, which is the criterion established in March 1989 (Nguyen 1989) for placing a tank on the Ferrocyanide Watch List.

Tanks 241-BX-102 and -106 were among the first tanks constructed and placed into service after the original tank farms (B, C, T, U) were built. The BX farm was built in 1946-1947, and these tanks were placed into service in 1948-1949. These tanks each have a capacity of 530,000 gallons. Their early process history is very similar and relatively simple. They received and stored bismuth phosphate metal waste (MW) from 1948-1954. They were emptied of metal waste for uranium recovery by sluicing in 1954-1955. Scavenged uranium recovery [tributyl phosphate (TBP)] supernatant was received and stored in 1956-1957, after settling was completed in the 241-BY tank farm. Aluminum decladding waste was added and stored from 1962-1967.

In July and August 1956, tank 241-BX-102 received a single 439,000 gal transfer of scavenged waste supernatant from tank 241-BY-107, one of the 24 ferrocyanide tanks. This batch (39-107-BY) was "sidepocketed" in tank 241-BX-102, rather than being disposed to ground since it contained a ^{60}Co concentration 10 to 50 times the crib disposal limit. The ^{90}Sr and ^{137}Cs concentrations were acceptable for disposal, as noted in the letters in the Appendix for scavenged batch 39-107-BY. The "sidepocketing" allowed tank 241-BY-107 to resume its function of receiving and settling scavenged waste from the uranium recovery process in U Plant. The transfer was entirely supernatant and the batch was disposed to ground (to the BC-12 and BC-13 trenches) on a specific retention[4] basis in December 1956.

[4]Specific retention means that the volume of liquid added to the ground disposal site is controlled so that the liquid is held within the soil column void volume (i.e. the liquid disposed never reaches the groundwater).

Considering the most extreme case, 5.5 % of the added ferrocyanide remained soluble in the supernatant and subsequently precipitated by some mechanism in 241-BX-102. The inventory in the tank would be:

$$439{,}000 \text{ GAL} \times 3.785 \frac{\text{LITER}}{\text{GAL}} \times 0.005 \frac{\text{G-MOLES}}{\text{LITER}} \times 0.055 = 456 \text{ G-MOLES}$$

which falls well below the 1000 g-moles criteria.

From 1967-1971, tank 241-BX-102 received primarily low level B Plant waste, along with small amounts of cladding waste, evaporator bottoms, and organic wash waste. All of these were non-ferrocyanide wastes. In 1971, tank 241-BX-102 was determined to be a leaker tank and diatomaceous earth was added to the tank to absorb the remaining mobile liquid. The tank received no more transfers for the remainder of its active service life. Tank 241-BX-102 was stabilized and isolated in 1977. A detailed description of the tank's transfer history can be found in Jungfleisch (1984) and Anderson (1990). Waste transfer data for this tank is included in Section 3.0.

In June 1956, tank 241-BX-106 received a single 524,000 gal transfer from tank 241-BY-108, also on the Ferrocyanide Watch List. This batch (36-108-BY) was sidepocketed for the same reasons as those noted for batch 39-107-BY. The ^{60}Co concentration was a factor of 10 to 20 above the cribbable limit. The ^{90}Sr and ^{137}Cs concentrations were acceptable (refer to letters in the Appendix regarding scavenged batch 36-108-BY). The transfer was entirely supernatant and was transferred to tank 241-BY-102 in September 1957. Again, assuming a worst case scenario, the maximum ferrocyanide inventory would still be below the 1000 g-moles criteria:

$$524{,}000 \text{ GAL} \times 3.785 \frac{\text{LITER}}{\text{GAL}} \times 0.005 \frac{\text{G-MOLES}}{\text{LITER}} \times 0.055 = 545 \text{ G-MOLES}$$

The material in tank 241-BY-102 was disposed to ground (the BC trenches), on a specific retention basis, in September-October 1957. From 1968-1976, tank 241-BX-106 received transfers of non-ferrocyanide waste from many tanks, and some of this accumulated waste was distributed to other tanks. From the fourth quarter of 1974 to the second quarter of 1976, tank 241-BX-106 received transfers of non-ferrocyanide waste from ferrocyanide tanks 241-BY-107, -110, and -112 while these tanks were in the In Tank Solidification (ITS) service. The scavenged supernatant from these tanks had been disposed to ground previously and other waste types were stored in the tanks. These transfers were relatively small and are not believed to have moved any ferrocyanide solids, based upon TRAC (Jungfleisch 1984) and Anderson (1990). Tank 241-BX-106 was removed from active service in 1980. The history of the tank's transfers by quarter is given in Section 3.0 (Anderson 1990).

The records indicate that tanks 241-BX-102 and -106 did not participate in the settling or collection of ferrocyanide solids. All available applicable documentation indicates that this is true (GE 1958; Borsheim and Simpson 1991; letters in the appendix). Settling and disposal of all process batches are traceable (Borsheim and Simpson 1991). Additionally, documentation from the ferrocyanide scavenging program showed that large amounts of sludge could not be moved unknowingly or unintentionally from tank to tank (Carpenter 1954; Clukey 1955). A model designed to simulate the ferrocyanide scavenging effort revealed that the transfer from ferrocyanide tank 241-BY-107 to 241-BX-102 and the transfer from ferrocyanide tank 241-BY-108 to 241-BX-106 contained only supernatant (Borsheim and Simpson 1991). The later transfers of waste from the BY farm ferrocyanide tanks to 241-BX-106 did not transfer any meaningful amount of ferrocyanide solids.

2.2.2 Tanks 241-BX-110 and 241-BX-111

Tanks 241-BX-110 and -111 are on the Ferrocyanide Watch List because the TRAC report listed them as having a 1000 g-moles ferrocyanide inventory.

Tanks 241-BX-110 and -111 were among the first tanks constructed and placed into service after the original tank farms (B, C, T, U) were built. The BX farm was built in 1946-1947 and these tanks were placed into service in 1949-1950. These tanks each have a capacity of 530,000 gallons. The initial waste received and stored was first decontamination cycle waste from the B Plant bismuth phosphate process (1949-1954). This first decontamination cycle waste supernatant was discarded to ground in 1954 (Ruppert and Heid 1954).

Tank 241-BX-110 received evaporator bottoms waste in 1954 and stored this waste until 1957. The supernatant from these evaporator bottoms was In Farm scavenged after transfer to the CR Vault in 1957. The ferrocyanide solids produced from this scavenging were settled and stored in tank 241-C-111. The next waste added to 241-BX-110 was cladding waste in 1964. The cladding waste supernatant was transferred from the tank in 1968 and ion exchange waste from B Plant added in 1969. For the rest of its service life there was limited activity in 241-BX-110. No documented transfers from a known or suspected ferrocyanide tank occurred from 1954-1972. However, as a part of its service history, this tank was part of the ITS program from 1972-1976 and it received supernatant transfers from other tanks in the BY farm. The tank was removed from active service in 1980.

After the first decontamination cycle waste supernatant was disposed, tank 241-BX-111 was filled with evaporator bottoms waste (1954-1957). After transfer to the CR Vault, the supernatant from these evaporator bottoms underwent In Farm scavenging in 1957. The ferrocyanide solids produced from this scavenging were settled and stored in tank 241-C-109. The tank was inactive from 1958-1964. In 1964, tank 241-BX-111 received a transfer of cladding waste, reportedly from 241-C-108, a ferrocyanide tank. The last batch of ferrocyanide scavenging supernatant in 241-C-108 was disposed to ground in January 1958. Tank 241-C-108 was then filled with aluminum cladding waste in 1960. The 1964 transfer to 241-BX-111 involved only supernatant, and no sludge was intentionally transferred. From 1964 to 1968, there was no tank activity in 241-BX-111. From 1968 to 1972, there were some intra-tank farm (BX farm) transfers. From 1972-1976, this tank also participated in the ITS program. The tank was removed from active service in 1980. A detailed description of the tank's transfer history can be found in Jungfleisch (1984) or Anderson (1990). Waste transfer data on these tanks is presented in Section 3.0.

The available historic records indicate that tanks 241-BX-110 and -111 never received ferrocyanide scavenged waste, either as supernatant or unsettled solids (GE 1958; Borsheim and Simpson 1991). Settling and disposal of all process batches are traceable (Borsheim and

Simpson 1991) and documentation from the ferrocyanide scavenging program shows that large amounts of sludge could not be moved unknowingly or unintentionally from tank to tank (Carpenter 1954; Clukey 1955). The later ITS transfers of waste from the BY farm ferrocyanide tanks to tanks 241-BX-110 and -111 did not transfer any meaningful amount of ferrocyanide solids (Borsheim and Simpson 1991). Tanks 241-BX-110 and -111 were erroneously listed in the TRAC report and there exists no technical basis for placing these tanks on the Ferrocyanide Watch List.

2.2.3 Tank 241-BY-101

Tank 241-BY-101 is on the Ferrocyanide Watch List because the TRAC report listed it as containing a 1000 g-moles ferrocyanide inventory. Tank 241-BY-101 is among the second generation of tanks constructed and placed into service after the original tank farms (B, C, T, U) were built. These tanks were built in 1948-1949 and placed into service in 1950-1952. The BY tanks have an increased capacity (750,000 gallons) and greater operating height. The tank's early process history is very similar to most of the BY farm tanks and is relatively simple. It received and stored bismuth phosphate metal waste (MW) from 1948-1954 and was sluiced for uranium recovery in 1954. It was used to store "sidepocketed" scavenged uranium recovery (TBP) supernatant from tank 241-BY-108 from 1955-1957. It was filled with and stored cladding waste from 1960-1965. During 1965-1967, tank 241-BY-101 was part of the ITS process loop as the original ITS-1 tank. After 1966, the ITS-1 equipment was transferred to tank 241-BY-102 and 241-BY-101 was allowed to cool. Evaporator (ITS) bottoms were added to 241-BY-101 in 1969 and 1971, and it was connected in 1972 as part of the ITS bottom loop until that system was shut down in 1976. Tank 241-BY-101 was stabilized and isolated in 1977. A detailed description of the tank's transfer history can be found in Jungfleisch (1984) or Anderson (1990). Waste transfer data for tank 241-BY-101 is presented in Section 3.0.

In March-April 1955, tank 241-BY-101 received a 681,000 gal transfer from ferrocyanide tank 241-BY-108 (the supernatant from batch 6-108-BY). This batch was too high in ^{90}Sr to dispose to the crib (see the H. V. Clukey letter in the Appendix) and it was sidepocketed so that 241-BY-108 could continue to function as a scavenged waste receiver/settling tank. Using an extremely conservative estimate, the maximum ferrocyanide inventory which could have been transferred would be:

$$681{,}000 \text{ GAL} \times 3.785 \frac{\text{LITER}}{\text{GAL}} \times 0.005 \frac{\text{G-MOLES}}{\text{LITER}} \times 0.055 = 709 \text{ G-MOLES}$$

which is below the 1000 g-moles criteria.

Later, in 1955, tank 241-BY-101 was filled with backup from overfilling tank 241-BY-102, which also contained sidepocketed scavenged supernatant (tank 241-BY-102 is not on the Ferrocyanide Watch List). This material was entirely supernatant and was transferred to the CR Vault in July 1957 and In Farm scavenged for ^{60}Co and ^{90}Sr as batches 15-112C-102BY and 16-109C-102BY. No ferrocyanide ion was added to these In Farm scavenged batches. After settling, the supernatant from these batches was disposed to the BC-6 crib in August 1957.

The records do not indicate that this tank ever participated in the settling or collection of ferrocyanide solids and all available applicable documentation indicates that this is true (GE 1958; Borsheim and Simpson 1991; letters in the Appendix). There is traceability for the settling and disposal of all process batches (Borsheim and Simpson 1991). Additionally, a model designed to simulate the ferrocyanide scavenging effort shows that the transfers from the ferrocyanide tanks to tank 241-BY-101 during the scavenging program were entirely supernatant. The later transfers of ITS waste from other BY farm ferrocyanide tanks to 241-BY-101 are not believed to have transferred any meaningful amount of ferrocyanide solids (Borsheim and Simpson 1991).

2.2.4 Tank 241-T-101

Tank 241-T-101 is on the Ferrocyanide Watch List because it was one of the original 14 tanks identified as containing ferrocyanide (Burger 1984; Pickett 1984). The TRAC report (Jungfleisch 1984) shows this tank as containing only 90 g-moles of ferrocyanide.

Tank 241-T-101 is one of the original 530,000 gallon tanks constructed in 1943-1944. It received metal waste, as the first tank in a three tank cascade, from the bismuth phosphate process in T Plant in December 1944 (Anderson 1990). The cascade was filled by February 1946 and the waste was undisturbed until it was sluiced for uranium recovery in U Plant in 1953 (Anderson 1990; Rodenhizer 1987).

Tank 241-T-101 received the scavenged waste from the October 1953 U Plant test of the ferrocyanide scavenging process. It was reported (Abrams 1956) that the scavenged waste solution (530,000 gals) was made 0.005 $\underline{M}$ $Fe(CN)_6^{-4}$ and 0.005 $\underline{M}$ Ni^{+2}, which would yield 10,000 g-moles of $NiFe(CN)_6^{-2}$. Approximately the upper half of the supernatant (255,000 gal) was discharged to a crib since sample results from the lower levels in the tank were above crib limits.

The remaining supernatant in 241-T-101 was transferred to tank 241-T-107. Anderson (1990) reports that in the last quarter of 1953 the remainder of the supernatant, except for the heel, was pumped to 241-T-107 and the tank was flushed three times to 241-T-107. The Hanford Site monthly report for December 1953 (HAPO 1954a) reports that 241-T-101 was skimmed down to 7% ($\approx$35,700 gal) of the original waste volume using a floating suction pump. The Hanford Site monthly for March 1954 (HAPO 1954b) estimated that 241-T-101 still contained 50% of the original precipitate. This implies that 50% (5,000 g-moles) was transferred to 241-T-107.

Note that the reason for emptying 241-T-101 was to allow it to again receive bismuth phosphate metal waste from T Plant. Some hot laboratory work was performed to assure that metal waste could be put on top of the ferrocyanide heel (HAPO 1954b). The tank was refilled with metal waste in 1955, sluiced again in 1956, and the waste was processed through the U Plant uranium recovery process (Anderson 1990 and Rodenhizer 1987). Sluicing of the metal waste from the tanks was done carefully to recover as much of the valuable uranium-bearing waste as possible. Two sluicers (300 gpm each), operating simultaneously, were used to break-up and slurry the tank solids after removing the overlying liquid to expose the solids (Rodenhizer 1987). The bulk of the slurry was removed from the tanks with a sludge pump that operated concurrently with the sluicers. A heel jet was installed to the centerline bottom of these dish-bottomed tanks to remove the slurry remaining below the sludge pump suction.

The typical heel remaining after sluicing to empty out the tanks was less than 2000-3000 gal. This estimate is based on discussions with operating personnel of the day, and the observation that sluicing of the 241-A-AX-AY farm tanks in the late 1960s to mid 1970s produced comparable heels. These later generation flat-bottomed tanks with air lift circulators installed to the tank bottom were much more difficult to sluice than the dish-bottomed tanks (Tank 241-T-101 is a dish-bottomed tank with the centerline bottom 12 inches lower than the bottom at the sides of the tank). Refilling tank 241-T-101 with metal waste would add approximately 132,500 gal of metal waste sludge (General Electric 1951) to the ferrocyanide sludge heel for a total solids volume of approximately 168,200 gal. The ferrocyanide sludges have no physical properties which would resist mixing and dilution (Jeppson and Wong 1993). During subsequent sluicing, the scavenged waste solids and metal waste solids would be mixed. Therefore, if a maximum heel of 3000 gal remained after sluicing and complete mixing is assumed, the tank would contain much less than 1000 g-moles of ferrocyanide:

$$5000 \text{ G-MOLES} \times \frac{3{,}000 \text{ GAL}}{168{,}200 \text{ GAL}} = 90 \text{ G-MOLES}$$

Even if no mixing is assumed, the maximum concentration of ferrocyanide left in the tank would be:

$$5000 \text{ G-MOLES} \times \frac{3{,}000 \text{ GAL}}{35{,}700 \text{ GAL}} = 420 \text{ G-MOLES}$$

Anderson (1990) shows 241-T-101 as containing a small heel of aluminum decladding waste (45,000-60,000 gals) from 1957 to 1963, when it was filled with the same type of waste from tank 241-U-108, a non-ferrocyanide tank. The tank was pumped to a 90,000 gal heel to tank 241-T-103 in 1969. In 1972 the tank received various wastes including B Plant low level waste, ion exchange waste, evaporator bottoms, and Reduction Oxidation (REDOX) Plant waste. All these were non-ferrocyanide wastes. Generally these wastes were routed from another tank rather than being received directly from a processing facility. Transfers to 241-T-102 and 241-T-103 were made in 1972. Transfers from 241-T-103 and 241-T-106 (both non-ferrocyanide tanks) were received in 1974, including decontamination waste; and a transfer was made to the 241-S-110 tank. In 1975, tank 241-T-101 began to receive waste from other T farm tanks as these tanks were removed from service (this included waste from the 200 series T farm tanks; see Section 3.0). The only transfers to 241-T-101 from a tank on the Ferrocyanide Watch List were from 241-T-107 in 1976 (two transfers totaling 220,000 gal). Records indicate that these transfers consisted only of supernatant and no solids were transferred.

Tank 241-T-101 was declared a leaker in 1992 and stabilized (pumpable liquid removed) in 1993 following authorization by the DOE. Section 4.0 contains the documentation that was evaluated for this authorization.

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SECTION 3.0

WASTE TRANSFER HISTORIES FOR TANKS

241-BX-102
241-BX-106
241-BX-110
241-BX-111
241-BY-101
241-T-101

Data From WHC-MR-0132 (Anderson 1990)
Westinghouse Hanford Company
Richland, Washington

Waste Status Summary of 102-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1948	---	---	---	---	
2	MW	111	---	---	Cascade begain filling June
3	MW	523	---	---	Cascade full in September
4	MW	523	---	---	
1-1949	MW	523	---	---	Cascade full
2	MW	523	---	---	Cascade full
3	MW	523	---	---	Cascade full
4	MW	523	---	---	Cascade full
1-1950	MW	523	---	---	Cascade full
2	MW	523	---	---	Cascade full
3	MW	523	---	---	Cascade full
4	MW	523	---	---	Cascade full
1-1951	MW	523	---	---	Cascade full supernate jetting from 103 to 102, then cascades to 101-BY
2	MW	523	---	---	Cascade full
3	---	---	---	---	
4	---	---	---	---	
1-1952	---	---	---	---	
2	MW	467	---	---	
3	MW	467	---	---	
4	MW	467	---	---	
-1953	MW	467	---	---	
2	MW	380	---	---	MW removal in progress
3	MW	346	346	---	MW removal in progress
4	MW	386	386	---	Rec'd MW supervantant from 103-B, MW removal in progress

Waste Status Summary of 102-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1954	MW	136	136	---	MW removal in progress
2	MW	12	12	---	MW removal in progress
3	---	0	---	---	Sludge only remaining
4	---	0	---	---	
1-1955	---	0	---	---	
2	---	0	---	---	
3	---	0	---	---	
4	---	0	---	---	
1-1956	---	0	---	---	
2	---	0	---	---	
3	TBP	439	439	---	Rec'd from 107-BY
4	TBP	43	43	---	344 to 12 BC ditch, 57 to 13 BC ditch
1-1957	TBP	51	51	---	Latest electrode reading
2	TBP	51	51	---	
3	TBP	51	51	---	
4	TBP	51	51	---	
1958	TBP	54	54	---	Latest electrode reading
	TBP	57	57	---	Latest electrode reading
3	TBP	54	54	---	Latest electrode reading
4	TBP	54	54	---	
1-1959	TBP	54	54	---	
2	TBP	54	54	---	
3	TBP	54	54	---	
4	TBP	54	54	---	
1-1960	TBP	54	54	---	
2	TBP	54	54	---	
3	TBP	54	54	---	
4	TBP	54	54	---	
1-1961					
2	TBP	57	57	---	6 month report
3					
4	TBP	59	59	---	Latest electrode reading 6 month report
1-1962					
2	TBP-CW	359	59-300	---	300 from 102-C and 103-C
3					6 month report
4	TBP-CW	549	59-490	---	190 from 102-C 6 month report

Waste Status Summary of 102-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1963					
2	TBP-CW	549	59-490	---	6 month report
3					
4	TBP-CW	549	59-490	---	6 month report
1-1964					
2	CW	549	454	95	6 month report
3					
4	CW	549	454	94	6 month report
1-1965					
2	CW	543	481	62	New elect.
3	CW	543	481	62	
4	CW	543	481	62	
1-1966	CW	543	481	62	
2	CW	543	481	62	
3	CW	543	481	62	
4	CW	546	484	62	
1967	CW	546	484	62	
2	CW	546	484	62	
3	CW	546	484	62	
4	CW	543	481	62	
1-1968	CW	513	481	62	673 to cell 23 conc.
2	CW	539	477	62	550 to 103-BY, 576 from 103-BX
3	CW-EB	426	89-275	62	667 from 101 & 103-BX, 780 to 103-TY
4	CW-BL	520	151-308	61	94 from 101-BX
1-1969	CW-BL	520	151-306	63	
2	CW-BL	520	151-297	72	
3	CW-BL	487	137-299	51	
4	CW-BL	508	187-281	40	1909 from 103-BX, 1888 to 103-BY
1-1970	CW-OWW	233	63-135	35	644 to 109-BY, 1394 from 103-BX, 608 to 103-BY, 399 to 102-BY
2 *	BL	41	6	35	413 from 103-BX, 602 to 109-BY
3 **	---	40	0	40	
4	---	40	0	40	
1-1971	---	40	0	40	
2	---	40	0	40	Tank leaks
3	---	40	0	40	Tank leaks
4	---	41	0	41	Tank leaks approximately 105 tons of diatomaceous earth added to the tank

eak detection dry wells drilled:

*21-02-01	*21-02-06	**21-27-01	**21-27-07	**21-27-10
21-02-03	21-02-07	21-27-02	21-27-08	
21-02-04	21-02-11	21-27-06	21-27-09	

Waste Status Summary of 102-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1972	---	41	0	41	Tank leaks
2	---	41	0	41	Tank leaks; contains diatomaceous earth
3	---	41	0	41	Tank leaks; contains diatomaceous earth
4	---	41	0	41	Tank leaks; contains diatomaceous earth
1-1973	---	41	0	41	Tank leaks; contains diatomaceous earth
2	---	41	0	41	Tank leaks; contains diatomaceous earth
3	---	41	0	41	Tank leaks; contains diatomaceous earth
4	---	41	0	41	Tank leaks; contains diatomaceous earth
1-1974	---	41	0	41	Tank leaks; contains diatomaceous earth
2	---	41	0	41	Tank leaks; contains diatomaceous earth
3	---	41	0	41	Tank leaks; contains diatomaceous earth
4	---	40	0	40	Tank leaks; contains diatomaceous earth
1-1975	---	40	0	40	Tank leaks; contains diatomaceous earth
2	---	40	0	40	Tank leaks; contains diatomaceous
	---	40	0	40	Tank leaks; contains diatomaceous
[illegible]	---	40	0	40	Tank leaks; contains diatomaceous earth
1-1976	---	40	0	40	Tank leaks; contains diatomaceous earth
2	---	40	0	40	Tank leaks; contains diatomaceous earth
3	---	40	0	40	Cont. desiccant
4	---	40	0	40	Leaker desicant add cmp
1-1977	---	40	0	40	Stabilized and isolated; leaks
2	---	40	0	40	Stabilized and isolated; leaks
3	---	40	0	40	Stabilized Phase I, Isolated Phase A
4	---	40	0	40	Stabilized Phase I, Isolated Phase A

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Waste Status Summary of 102-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1978	-	40	0	40	Leaker - Primary Stabilized Interim Isolated
2-	-	40	0	40	
3-	-	40	0	40	
4-	-	40	0	40	New Photo 11/13/78
1-1979	-	40	0	40	
2-	-	40	0	40	
3-	-	40	0	40	
4-	-	40	0	40	
1-1980	-	40	0	40	
2-	-	40	0	40	
3-	-	40	0	40	
4-	-	40	0	40	

106-BX-1

Waste Status Summary of 106-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
I-1949	---	---	---	---	
2	---	---	---	---	
3	MW	78	---	---	Cascade began filling September
4	MW	470	---	---	Cascade
I-1950	MW	523	---	---	Cascade filled in January
2	MW	523	---	---	Cascade full
3	MW	523	---	---	Cascade full
4	MW	523	---	---	Cascade full
I-1951	MW	523	---	---	Cascade full
2	MW	523	---	---	Cascade full
3	---	---	---	---	
4	---	---	---	---	
I-1952	---	---	---	---	
2	MW	530	---	---	
3	MW	530	---	---	
4	MW	530	---	---	
I-1953	MW	530	---	---	
2	MW	530	---	---	
3	MW	530	530	---	
4	MW	530	530	---	

Waste Status Summary of 106-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1954	MW	530	530	---	
2	MW	530	530	---	
3	MW	1	1	---	Supernatant supply for 109-BY, pumped to 109-BY
4	MW	1	1	---	
1-1955	MW	34	34	---	
2	---	0	---	---	
3	---	0	---	---	
4	---	0	---	---	
1-1956	---	0	---	---	
2	TBP	524	524	---	Filled from 108-BY
3	TBP	524	524	---	
4	TBP	524	524	---	
1-1957	TBP	505	505	---	Latest electrode reading
2	TBP	521	521	---	Latest electrode reading
3	TBP	57	57	---	Latest electrode reading, 467 to 107-BY
4	TBP	57	57	---	
1-1958	TBP	57	57	---	
2	TBP	57	57	---	
3	TBP	57	57	---	
4	TBP	57	57	---	
1-1959	TBP	98	98	---	New electrode reading
2	TBP	98	98	---	
3	TBP	98	98	---	
4	TBP	98	98	---	
1-1960	TBP	98	98	---	
2	TBP	98	98	---	
3	TBP	98	98	---	
4	TBP	98	98	---	
1-1961					
2	TBP	98	98	---	
3					
4	TBP	98	98	---	
1-1962					
2	TBP	98	98	---	
3					
4	TBP	98	98	---	
1-1963					
2	TBP-CW	541	98-443	---	443 from 102-C 6 month report
3					
4	TBP-CW	541	98-443	---	6 month report

Waste Status Summary of 106-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1964					
2	TBP-CW	541	98-443	---	
3					
4	TBP-CW	543	98-445	---	
1-1965					
2	TBP-CW	543	44-445	54	
3	TBP-CW	543	44-445	54	
4	TBP-CW	543	44-445	54	
1-1966	TBP-CW	543	44-445	54	
2	TBP-CW	543	44-445	54	
3	TBP-CW	543	44-445	54	
4	TBP-CW	543	44-445	54	
1-1967	TBP-CW	541	44-443	54	
2	TBP-CW	541	44-443	54	
3	CW	65	11	54	476 to 103-BY
4	CW	62	8	54	
968	CW-EB IX	480	79-205-142	54	Received 418 from 104-BX
2	CW-EB IX	480	79-205-142	54	
3	EB-CW	403	50-299	54	408 from 111-BX & 112-BX, 485 to 103-BY
4	---	33	0	33	1782 from BX Farm, 2152 to 103-BY
1-1969	IX	550	517	33	516 from 104-BX
2	IX	552	519	33	
3	IX	517	517	0	
4	IX	516	516	0	
1-1970	IX	514	514	0	
2	IX-BL	334	35-299	0	479 to 104-BX, 299 from 101-BX
3	IX-BL	334	35-299	0	
4	BL-OWW-RIX	541	100-204-200	37	1251 from 101-BX, 1048 to 103-TY T
1-1971	EB-SIX	411	74-294	43	1027 from 101-BX, 356 to 103-BY, 798 to 118-TX
2 *	BL-CW-OWW-RIX	495	111-48-52-241	43	2297 from 101-BX, 1205 to 101-TX, 966 to 105-TX, 43 to 102-BY
3	BL-CW-OWW-RIX	466	104-45-49-225	43	30 to 109-BY
4	BL-CW-OWW-RIX	466	102-44-48-221	51	
1-1972	BL-CW-OWW-RIX	465	104-45-49-227	65	
2	BL-CW-OWW-RIX	318	68-29-32-149	40	
3	BL-CW-OWW-RIX	202	47-20-22-103	10	104 to 103-BX
	BL-CW-OWW-IX	200	14-6-6-164	10	133 from 105-BX, 132 to 103-BX
1-1973	BL-CW-OWW-IX	73	5-2-2-54	10	10 flush water, 133 to 103-BX
2	BL-CW-OWW-IX	347	5-2-2-328	10	17 from 105-BX, 271 from 109-BX
3	BL-CW-OWW-IX	348	5-2-2-329	10	
4	BL-CW-OWW-IX	348	5-2-2-329	10	

* Leak detection dry wells drilled: 21-06-01; 21-06-02; 21-06-03; 21-06-10

Waste Status Summary of 106-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1974	BL-CW-OWW-IX	394	5-2-2-375	10	43 from 108-BX
2	BL-CW-OWW-IX	182	26-1-1-144	10	64 from 101-B, 2 from 108-BX, 277 to 107-S
3	BL-CW-OWW-IX	251	26-1-1-213	10	1 from 108-BX, 66 from 107-BX
4	BL-CW-OWW-IX-EB	315	25-1-1-201-61	26	1 from 108-BX, 61 from 112-BY
1-1975	BL-CW-OWW-IX-EB	464	25-1-1-201-210	26	1 water, 25 from 107-BY, 123 from 110-BY
2	EB-IX-BL	230	170-30-4	26	114 from 110-BY, 66 from 112-BY, 413 to 106-SX
3	EB-IX-BL	230	170-30-4	26	
4	EB-IX-BL	230	170-30-4	26	
1-1976	EB-IX-BL	277	217-30-4	26	6 from 112-BY
2	EB-IX-BL	323	240-53-4	26	46 from 112-BY
3	EVAP	323	297	26	Lo Heat
4	EVAP	101	75	26	Lo Heat
1-1977	EVAP	233	207	26	Active - space - low heat
2	EVAP	70	44	26	Active - space - low heat
3	EVAP	43	14	29	Inactive current
	EVAP	43	14	29	Inactive current - open hole salt we.

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Waste Status Summary of 106-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1978	-	43	14	29	Inactive-Open Hole Salt Well
2-	NCPLX	43	14	29	
3-	NCPLX	43	14	29	
4-	NCPLX	43	14	29	Pmp w/flx float new photo 11/2/78
1-1979	NCPLX	43	14	29	
2-	NCPLX	43	14	29	
3-	NCPLX	43	14	29	
4-	NCPLX	43	14	29	
1-1980	NCPLX	43	14	29	
2-	NCPLX	43	14	29	
3-	NCPLX	43	14	29	
4-	NCPLX	43	14	29	

Waste Status Summary of 110-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1949	---	---	---	---	
2	---	---	---	---	
3	1C	66	---	---	Began filling September.
4	1C	414	---	---	
1-1950	1C	523	---	---	Cascade full in January.
2	1C	523	---	---	Full.
3	1C	523	---	---	Full.
4	1C	523	---	---	
1-1951	1C	523	---	---	
2	1C	523	---	---	
3	---	---	---	---	
4	---	---	---	---	
1-1952	---	---	---	---	
2	1C	530	---	---	
3	1C	530	---	---	
4	1C	530	---	---	

Waste Status Summary of 110-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1963					
2	1C-EB	395	39-159	197	6 month report
3					
4	1C-EB	392	39-156	197	Latest electrode reading.
					6 month report
1-1964					
2	1C-EB	392	39-156	197	6 month report
3					
4	1C-EB-CW	546	39-156-154	197	154 CW from 102-C.
					6 month report
1-1965					
2	EB-CW	543	115-151	277	
3	EB-CW	543	115-151	277	
4	EB-CW	543	115-151	277	
1-1966	EB-CW	543	115-151	277	
2	EB-CW	543	115-151	277	
3	EB-CW	543	115-151	277	
4	EB-CW	543	115-151	277	
167	EB-CW	543	115-151	277	
	EB-CW	543	115-151	277	
	EB-CW	543	115-151	277	
4	EB-CW	543	115-151	277	
1-1968	EB-CW	554	115-162	277	Received 11 from Catch Tank.
2	EB-CW	554	115-162	277	
3	EB-CW	554	115-162	277	
4	EB	315	38	277	239 to 106-BX.
1-1969	EB-IX	542	36-229	277	229 from 221-B (18-1)
2	EB-IX	542	36-229	277	
3	EB-IX	509	124-229	156	
4	EB-IX	509	124-229	156	
1-1970	EB-IX	509	124-229	156	
2	EB	224	68	156	285 to 104-BX.
3	EB	227	71	156	
4	EB	227	71	156	
1-1971	EB	227	71	156	
2	EB	231	75	156	
3*	EB	224	68	156	
4	EB	231	75	156	
72	EB	464	174	290	ITS bottoms and recycle.
	EB	491	264	227	ITS bottoms and recycle.
3	EB	492	265	227	ITS bottoms and recycle.
4	EB	494	267	227	ITS bottoms and recycle.

* Leak detection dry wells drilled: 21-10-01; 21-10-05; 21-10-07; 21-10-11

Waste Status Summary of 110-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1953	1C	530	---	133	
2	1C	530	---	133	
3	1C	530	397	133	
4	1C	322	189	133	
1-1954	1C	276	0	276	
2	EB	530	294	236	Received from 105-B.
3	EB	530	294	236	Received from 105-B.
4	EB	530	294	236	
1-1955	EB	530	294	236	
2	EB	530	294	236	
3	EB	530	294	236	
4	EB	530	294	236	
1-1956	EB	530	294	236	
2	EB	530	294	236	
3	EB	530	294	236	
4	EB	530	294	236	
57	EB	497	261	236	Latest electrode reading.
2	EB	527	279	248	Latest electrode reading.
3	EB	527	279	248	
4	---	326	0	326	201 Scavenged.
1-1958	---	326	0	326	
2	EB	367	41	326	New electrode reading.
3	EB	367	41	326	
4	EB	367	41	326	
1-1959	EB	367	41	326	
2	EB	368	42	326	
3	EB	368	42	326	
4	EB	368	42	326	
1-1960	EB	368	42	326	
2	EB	368	42	326	
3	EB	368	42	326	
4	EB	368	42	326	
1-1961					
2	EB	367	41	326	6 month report
3					
4	EB	389	63	326	22 flush from BXR Vault. 6 month report
52					
	EB	392	66	326	Latest electrode reading.
3					6 month report
4	EB	395	69	326	Latest electrode reading. 6 month report

Waste Status Summary of 110-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1973	EB	510	283	227	ITS bottoms and recycle.
2	EB	514	276	238	ITS bottoms and recycle.
3	EB	501	263	238	ITS bottoms and recycle.
4 *	EB	499	261	238	ITS bottoms and recycle.
1-1974	EB	499	211	288	ITS bottoms and recycle.
2	EB	500	212	288	ITS bottoms and recycle.
3	EB	500	212	288	ITS bottoms and recycle.
4	EB	499	250	249	ITS bottoms and recycle.
1-1975	EB	499	250	249	ITS bottoms and recycle.
2	EB	499	250	249	ITS bottoms and recycle.
3	EB	499	250	249	ITS bottoms and recycle.
4	EB	499	250	249	ITS bottoms and recycle.
1-1976	EB	499	250	250	ITS bottoms and recycle.
2	EB	499	250	249	ITS bottoms and recycle.
3	EVAP	499	250	249	Activity restricted.
4	EVAP	499	250	249	
1-1977	EVAP	499	250	249	(189 sludge & 60 salt cake) Evap. feed concentrate
2	EVAP	249		249	(189 sludge & 60 salt cake) Inactive salt well, pump salt well installed
3	EVAP	249	0	249	Inactive current, salt well installed
4	EVAP	249	0	249	Inactive current, salt well installed

* Leak detection dry well 21-10-03 drilled.

Waste Status Summary of 110-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1979	-	249	0	249	Inactive - Salt Well Installed
2-	-	249	0	249	Questionable Integrity Tank
3-	-	249	0	249	
4-	-	249	0	249	New Photo 11/14/78
1-1979	-	249	0	249	
2-	-	249	0	249	
3-	-	249	0	249	
4-	-	249	0	249	
1-1980	-	202	2	200	New Photo 2/19/80
2-	-	202	2	200	
3-	-	202	2	200	
4-	-	202	2	200	

Waste Status Summary of 111-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1950	1C	281	---	---	Cascade began filling January.
2	1C	523	---	---	Full in May.
3	1C	523	---	---	Full.
4	1C	523	---	---	
1-1951	1C	523	---	---	
2	1C	523	---	---	
3	---	---	---	---	
4	---	---	---	---	
1-1952	---	---	---	---	
2	1C	525	---	---	
3	1C	525	---	---	
4	1C	525	---	---	

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Waste Status Summary of 111-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1953	1C	525	---	---	
2	1C	530	---	---	
3	1C	530	530	---	
4	1C	530	530	---	
1-1954	1C	530	498	32	
2	1C-EB	256	41-183	32	Pumped to Crib No. 2.
3	1C-EB	530	41-457	32	
4	1C-EB	530	41-457	32	
1-1955	1C-EB	530	41-457	32	
2	1C-EB	530	41-457	32	
3	1C-EB	530	41-457	32	
4	1C-EB	530	41-457	32	
1-1956	1C-EB	530	41-452	32	
2	1C-EB	530	41-457	32	
3	1C-EB	530	41-457	32	
4	1C-EB	530	41-457	32	
957	1C-EB	535	41-462	32	Latest electrode reading.
	1C-EB	568	11-495	62	Latest electrode reading.
3	1C-EB	568	11-495	62	Latest electrode reading.
4	---	51	0	51	514 scavenged.
1-1958	---	51	0	51	
2	---	51	0	51	
3	---	51	0	51	
4	---	51	0	51	
1-1959	---	51	0	51	
2	---	51	0	51	
3	---	51	0	51	
4	---	51	0	51	
1-1960	---	51	0	51	
2	---	51	0	51	
3	---	51	0	51	
4	---	51	0	51	
1-1961					
2	---	51	0	51	6 month report
3					
4	1C	57	6	51	New electrode reading. 6 month report

Waste Status Summary of 111-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1963					
2	1C	57	6	51	6 month report
3					
4	1C	57	6	51	6 month report
1-1964					
2	1C-CW	544	6-487	51	487 from 108-C. 6 month report
3					
4	1C-CW	543	6-486	51	6 month report
1-1965					
2	CW	541	462	79	
3	CW	541	462	79	
4	CW	541	462	79	
1-1966	CW	541	462	79	
2	CW	541	462	79	
3	CW	541	462	79	
4	CW	541	462	79	
'67	CW	541	462	79	
	CW	541	462	79	
3	CW	541	462	79	
4	CW	541	462	79	
1-1968	CW	540	461	79	
2	CW	540	461	79	
3	CW	343	264	79	198 to 106-BX.
4	CW	107	28	79	236 to 106-BX.
1-1969	CW	107	28	79	
2	CW IX	390	28-283	79	283 from 104-BX.
3	CW IX	506	41-432	33	149 from 104-BX.
4	CW IX	505	41-431	33	
1-1970	CW IX	505	41-431	33	
2	CW IX	505	41-431	33	
3	CW	47	14	33	458 to 104-BX.
4	CW	48	15	33	
1-1971	CW	51	18	33	
2*	CW	47	14	33	
3	EB	102	69	33	
4	EB	235	202	33	

ak detection dry wells drilled:

21-11-04 21-11-10
21-11-05 21-11-11
21-11-07

Waste Status Summary of 111-BX Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1972	EB	395	277	118	ITS bottoms and recycle.
2	EB	362	294	68	ITS bottoms and recycle.
3	EB	363	295	68	ITS bottoms and recycle.
4	EB	400	332	68	ITS bottoms and recycle.
1-1973	EB	239	171	68	ITS bottoms and recycle.
2	EB	308	180	128	ITS bottoms and recycle.
3 *	EB	281	153	128	ITS bottoms and recycle.
4	EB	321	193	128	ITS bottoms and recycle.
1-1974	EB	387	153	234	ITS bottoms and recycle.
2	EB	404	170	234	ITS bottoms and recycle.
3	EB	508	274	234	ITS bottoms and recycle.
4	EB	508	292	216	ITS bottoms and recycle.
1-1975	EB	508	292	216	ITS bottoms and recycle.
2	EB	508	292	216	ITS bottoms and recycle.
3	EB	508	292	216	ITS bottoms and recycle.
4	EB	508	292	216	ITS bottoms and recycle.
76	EB	510	294	216	ITS bottoms and recycle.
2	EB	510	294	216	ITS bottoms and recycle.
3	EVAP	510	294	216	Activity restricted.
4	EVAP	510	294	216	
1-1977	EVAP	475	259	216	(68 sludge & 148 salt cake) Evap. feed concentrate salt well installed
2	EVAP	260	44	216	(68 sludge & 148 salt cake) Active restricted, Evap. feed conc. SW installec
3	EVAP	230	14	216	(68 sludge & 148 salt cake) Inactive current; salt well installed
4	EVAP	233	22	211	(68 sludge & 143 salt cake) Inactive current; salt well installed

* Leak detection dry well 21-11-03 drilled.

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Waste Status Summary of 111-BXTank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1978	-	233	22	211	Inactive - Salt Well Installed
2-	NCPLX	233	22	211	Questionable Integrity Tank
3-	NCPLX	233	22	211	
4-	NCPLX	233	22	211	
1-1979	NCPLX	233	22	211	
2-	NCPLX	233	22	211	
3-	NCPLX	233	22	211	
4-	-	233	22	211	
1-1980	NCPLX	233	22	211	New Photo 3/6/80
2-	NCPLX	233	22	211	
3-	NCPLX	233	22	211	
4-	NCPLX	233	22	211	

Waste Status Summary of 101-BY Tank Capacity 750,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1950	MW	290	290	---	Began filling March.
2	MW	661	661	---	
3	MW	744	744	---	Cascade full September.
4	MW	744	744	---	Cascade full September.
1-1951	MW	744	744	---	Cascade full.
2	MW	744	744	---	
3	---	---	---	---	
4	---	---	---	---	
1-1952	MW	758	758	---	
2	MW	758	758	---	
3	MW	758	758	---	
4	MW	758	758	---	
1-1953	MW	758	758	---	
2	MW	758	758	---	
3	MW	758	758	---	
4	MW	758	758	---	

Waste Status Summary of 101-BY Tank Capacity 750,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1954	MW	1	1	---	Transfer to 103-BY.
2	---	---	---	---	Was emptied on May 17, 1954.
3	---	---	---	---	
4	---	---	---	---	
1-1955	TBP	681	681	---	Received from 108-BY.
2	TBP	750	750	---	
3	TBP	750	750	---	
4	TBP	750	750	---	
1-1956	TBP	750	750	---	Scvg. waste awaiting rework.
2	TBP	750	750	---	Scvg. waste awaiting rework.
3	MW	750	750	---	
4	TBP	750	750	---	
1-1957	TBP	717	717	---	
2	TBP	262	262	---	
3	TBP	40	40	---	225m scavenged. Latest electrode reading.
4	TBP	40	40	---	
1-1958	TBP	40	40	---	
2	TBP	59	59	---	New electrode reading.
3	TBP	59	59	---	
4	TBP	59	59	---	
1-1959	TBP	59	59	---	
2	TBP	59	59	---	
3	TBP	59	59	---	
4	TBP	60	60	---	Latest electrode reading.
1-1960	TBP	60	60	---	
2	TBP	60	60	---	
3	TBP	60	60	---	
4	TBP	394	394	---	Received 275m CW from 108-C. Received 77m from 108-C.
1-1961	---	---	---	---	
2	TBP-CW	483	247 236	---	Received 89m from 108-C
3	---	---	---	---	
4	TBP- 1C-CW	728	247 439 42	---	Received 245m from 107-C.

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Waste Status Summary of 101-BY Tank Capacity 750,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1962	---	---	---	---	
2	TBP- 1C-CW	728	247- 439 42	---	
3	---	---	---	---	
4	TBP- 1C-CW	728	247- 439- 42	---	
1-1963	---	---	---	---	
2	TBP-1C- . CW	730	210- 439 44	37	
3	---	---	---	---	
4	TBP- 1C-CW	741	210- 439- 55	37	New electrode installed.
1-1964	---	---	---	---	
2	TBP- 1C-CW	744	210- 439- 58	37	
3-	---	---	---	---	
4	TBP 1C-CW	744	210- 439 58	37	
1-1965	---	---	---	---	
2	CW	582	582	0	762m ITS boil-off.
3	CW	601	601	---	502m ITS boil-off.
4	CW	541	541	---	293m ITS boil-off.
1-1966	CW	590	590	---	240m ITS boil-off.
2	CW	612	612	---	410m ITS boil-off.
3	CW	585	585	0	
4	CW	409	409	0	28m recovered butts.
1-1967	CW	409	409	0	Status not determined.
2	CW	407	409	0	Status not determined.
3	CW	407	298	109	Demonstrating solidification.
4	CW	406	30	376	Demonstrating solidification.

Waste Status Summary of 101-BY Tank Capacity 750,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1968	CW	406	28	378	Demonstrating solidification.
2	EB	406	28	378	Demonstrating solidification.
3	EB	407	29	378	Demonstrating solidification.
4	EB	407		29	
1-1969	EB	407	126	281	Demonstrating solidification.
2	EB	407	133	274	Demonstrating solidification.
3	EB	739	429	310	331 from 105-BY.
4	EB	737	405	332	Demonstrating solidification.
1-1970	EB	737	400	337	
2	EB	744	407	337	
3	EB	743	406	337	
4	EB	747	407	340	
1-1971	EB	745	405	340	
2	EB	733	347	386	769 from 108-BY; 782 to 101-BX.
3 *	EB	736	350	386	
4	EB	737	339	398	
1-1972	EB	737	339	398	ITS - bottoms and recycle.
2	EB	739	341	398	ITS - bottoms and recycle.
3	EB	740	322	418	ITS - bottoms and recycle.
4	EB	734	316	418	ITS - bottoms and recycle.
1-1973	EB	738	320	418	ITS - bottoms and recycle.
2	EB	737	319	418	ITS - bottoms and recycle
3	EB	738	320	418	ITS - bottoms and recycle.
4	EB	739	321	418	ITS - bottoms and recycle.
1-1974	EB	740	322	418	ITS - bottoms and recycle.
2	EB	746	328	418	ITS - bottoms and recycle
3 **	EB	748	330	418	ITS - bottoms and recycle
4	EB	747	349	398	ITS - bottoms and recycle 6 to 109-BY (1 water).
1-1975	EB	747	349	398	ITS - bottoms and recycle.
2	EB	728	330	398	ITS - bottoms and recycle 20 to 105-BX.
3	EB	728	330	398	
4	EB	728	330	398	ITS - bottoms and recycle.

* Dry Wells No.'s 22-01-01, 22-01-04, and 22-01-07 were drilled.

** Dry Wells No.'s 22-01-03, and 22-01-10 were drillled.

Waste Status Summary of 101-BY Tank Capacity 750,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1976	EB	728	330	398	
2	EB	728	330	398	ITS - bottoms and recycle.
3	EVAP.	733	335	398	ITS - bottoms and recycle.
4	EVAP.	579	181	398	Con. feed.
1-1977	EVAP.	458	60	398	Salt Well Pumped
2	EVAP.	447	8	439	" " "
3	EVAP.	447	8	439	Inactive Current
4	EVAP.	447	8	439	" "
1-1978	NCPLX	450	11	439	Inactive
2-	NCPLX	450	11	439	
3-	NCPLX	447	8	439	
4-	NCPLX	447	8	439	
1-1979	NCPLX	447	8	439	
2-	NCPLX	447	8	439	
3-	NCPLX	447	8	439	
4-	NCPLX	447	8	439	
1-1980	NCPLX	447	8	439	New Photo 3-20-80
2-	NCPLX	447	8	439	
3-	NCPLX	447	8	439	
4-	NCPLX	443	4	439	

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Waste Status Summary of 101-T Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid In Storage	Solids In Storage	Remarks
1-1944	---	---	---	---	
2	---	---	---	---	
3	---	---	---	---	
4	---	---	---	---	
1-1945	MW	135	---	---	101,102,103 in Cascade, began filling Dec. 44.
2	MW	317	---	---	101,102,103 in Cascade.
3	MW	527	---	---	101,102,103 in Cascade, began overflow to 102 in Sept.
4	MW	528	---	---	Cascade began overflow to 103 in Nov.
1-1946	MW	528	---	---	Cascade 103 full in Feb. 46.
2	MW	528	---	---	Cascade full.
3	MW	528	---	---	Cascade full.
4	MW	528	---	---	Cascade full.
1-1947	MW	528	---	---	Cascade full.
2	MW	528	---	---	Cascade full.
3	MW	528	---	---	Cascade full.
4	MW	528	---	---	Cascade full.
1-1948	MW	528	---	---	Cascade full.
2	MW	528	---	---	Cascade full.
3	MW	528	---	---	Cascade full.
4	MW	528	---	---	Cascade full.
1-1949	MW	528	---	---	Cascade full.
2	MW	528	---	---	Cascade full.
3	MW	528	---	---	Cascade full.
4	MW	528	---	---	Cascade full.
1-1950	MW	528	---	---	Cascade full.
2	MW	528	---	---	Cascade full.
3	MW	528	---	---	Cascade full.
4	MW	528	---	---	Cascade full.
1-1951	MW	528	---	---	Cascade full.
2	MW	528	---	---	Cascade full.
3	---	---	---	---	
4	---	---	---	---	

Waste Status Summary of 101-T Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid In Storage	Solids In Storage	Remarks
1-1952	---	---	---	---	
2	MW	530	---	---	
3	MW	530	---	---	
4	MW	530	---	---	
1-1953	MW	530	---	---	
2	MW	169	169	---	Metal waste removal in process.
3	---	---	---	---	
4	TBP	20	20	---	Unconcentrated, scavenged TBP waste for test. 256,000 gallons cribbed. Remainder except heel pumped to 107-T. Flushed 3 times to 107-T.
1-1954	---	---	---	---	
2	---	---	---	---	
3	---	---	---	---	
4	---	---	---	---	
1-1955	MW	417	417	---	Rec'd T Plant metal waste.
2	MW	530	530	---	
3	MW	530	530	---	
4	MW	530	530	---	
1-1956	MW	530	530	---	To be sluiced soon.
2	MW	20	10	10	Sluicing began this month.
3					Sluicing continued.
3	MW	3	1	2	Heel to be sluiced.
4	---	---	---	---	Active sluicing.
1-1957	---	---	---	---	
2	CW	59	59	---	New electrode reading.
3	CW	57	57	---	Latest electrode reading.
4	CW	57	57	---	
1-1958	CW	57	57	---	
2	CW	57	57	---	
3	CW	57	57	----	
4	CW	46	46	---	New electrode reading.
1-1959	CW	45	45	---	
2	CW	45	45	---	
3	CW	45	45	---	
4	CW	45	45	---	

Waste Status Summary of 101-T Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid In Storage	Solids In Storage	Remarks
1-1960	CW	45	45	---	
2	CW	45	45	---	
3	CW	45	45	---	
4	CW	48	48	---	
1-1961	---	---	---	---	
2	CW	51	51	---	
3	---	---	---	---	
4	CW	51	51	---	
1-1962	---	---	---	---	
2	CW	51	51	---	
3	---	---	---	---	
4	CW	51	51	---	
1-1963	---	---	---	---	
2	CW	507	507	---	432M from 108-U.
3	---	---	---	---	
4	CW	507	507	---	
1-1964	---	---	---	---	
2	CW	507	507	---	
3	---	---	---	---	
4	CW	532	532	---	
1-1965	---	---	---	---	
2	CW	535	535	---	
3	CW	535	535	---	
4	CW	535	535	---	
1-1966	CW	535	535	---	
2	CW	535	535	---	
3	CW	535	535	---	
4	CW	535	535	---	
1-1967	CW	535	535	---	
2	CW	535	535	---	
3	CW	535	535	---	
4	CW	535	535	---	
1-1968	CW	537	537	---	
2	CW	536	536	---	
3	CW	536	536	---	
4	CW	538	538	---	

Waste Status Summary of 101-T Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid In Storage	Solids In Storage	Remarks
1-1969	CW	539	539	---	
2	CW	92	92	---	447 to 103-T.
3	CW	94	94	---	
4	CW	94	57	37	
1-1970	CW	96	59	37	
2	CW	96	59	37	
3	CW	96	59	37	
4	CW	96	59	37	
1-1971	CW	97	60	37	
2	CW	96	59	37	
3	CW	97	60	37	
4	CW	98	61	37	
1-1972	CW	98	61	37	
2	CW	98	61	37	
3	BL-IX-EB-RIX-R	243	24-14-7-26-8	37	498 from 101-BX, 437 from 114-SX, 3 flush water, 489 to 102-T, 305 to 103-T.
4	BL-IX-EB-RIX-R	312	2-14-44-163-52	37	254 from 114-SX, 182 to 103-T.
1-1973	BL-IX-EB-RIX-R	312	2-14-44-163-52	37	
2 *	BL-IX-EB-RIX-R	340	2-15-48-180-58	37	
3	BL-IX-EB-RIX-R	311	2-14-43-163-52	37	
4	BL-IX-EB-RIX-R	312	2-14-43-164-52	37	
1-1974	BL-IX-EB-RIX-R	313	2-14-43-165-52	37	
2	BL-IX-EB-RIX-R	313	2-14-43-165-52	37	
3	CW-IX-EB-RIX-R-DW BL	259	11-84-18-65-20-5-19	37	139 from 103-T, 37 from 106-T, 230 to 110-S.
4	CW-IX-EB-RIX-R-DW BL	260	11-85-18-65-20-5-19	37	

* Dry Wells No.s 50-01-02, 50-01-04, 50-01-06, 50-01-09 and 50-01-12 were drilled.

Waste Status Summary of 101-T Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid In Storage	Solids In Storage	Remarks
1-1975	CW-IX-EB-BL-RIX-R-DW-BNW	189	4-63-7-33-26-8-2-9	37	122 from 108-T, 41 from 109-T, 230 from 106-SX.
2	CW-IX-EB-BL-RIX-R-DW-BNW	208	4-68-7-38-26-8-2-18	37	6 from 108-T, 12 from 109-T.
3	CW-IX-EB-BL-RIX-R-DW-BNW	208	4-68-7-38-26-8-2-18	37	
4	CW-IX-EB-BL-RIX-R-DW-BNW	208	4-68-7-38-26-8-2-18	37	
1-1976	224-CW-IX-EB-BL-RIX-R-DW-BNW	337	67-5-114-8-43-29-9-2-23	37	2 from 102-T, 15 from 104-T, 1 from 105-T, 31 from 107-T, 2 from 109-T, 9 from 110-T, 8 from 111-T, 21 from 201-T, 27 from 202-T, 1 from 203-T, 15 from Ct, 241-T-301-8 1 from 204T.
2	IX-224	329	209-83	37	2 from 102-T, 189 from 107-T, 3 from 109-T, 8 from 110-T, 5 from 111-T, 1 from 201-T, 1 from 202-T, 8 from 203-T, 5 from 204-T.
3	Evap.	387	350	37	
4	Evap.	403	366	37	Int. liquid storage.
1-1977	Evap.	156	116	40	" " " "
2	Evap.	161	121	40	" " " "
3	Evap.	222	160	62	" " " "
4	Evap.	249	146	103	" " " "

Waste Status Summary of 101-T Tank-Capacity 530,000 Gallons

Qtr.-Year	Type Waste	Total Vol.	Liquid in Storage	Solids in Storage	Remarks
1-1978	NCPLX	252	149	103	Active - Salt Well Recvr. Photo taken 3-15-78
2-	NCPLX	268	165	103	
3-	NCPLX	220	129	91	Solid Level Adjusted 9-10-78
4-	NCPLX	244	141	103	
1-1979	NCPLX	208	105	103	
2-	NPCLX	246	143	103	Photo taken 6-1-79
3-	NCPLX	246	143	103	Inactive
4-	NCPLX	246	143	103	
1-1980	NCPLX	131	28	103	
2-	NCPLX	131	28	103	
3-	NCPLX	131	28	103	
4-	NCPLX	131	28	103	

SECTION 4.0

DOCUMENTATION FOR STABILIZATION OF 241-T-101

Section 4.1

Safety Assessment for Pumping 241-T-101

Westinghouse
Hanford Company

P.O. Box 1970 Richland, WA 99352

September 30, 1992 9257308

Mr. R. E. Gerton, Project Manager
Tank Farm Project Office
U. S. Department of Energy
Richland Field Office
Richland, Washington 99352

Dear Mr. Gerton:

COMPLETION OF MILESTONE 2024: COMPLETE SAFETY ASSESSMENT FOR PUMPING FERROCYANIDE TANKS AND MILESTONE 2001: SUBMIT RECOMMENDATIONS ON INTERIM STABILIZATION OF FERROCYANIDE TANKS IN SUPPORT OF THE TPA

References:
(1) Letter, D. C. Richardson, WHC, to R. E. Gerton, RL, "Safety and Environmental Assessments for Pumping/Stabilization of Ferrocyanide Tanks (Milestone Number 2024)," 9256462, dated September 1, 1992.

(2) Letter, J. L. Deichman, WHC, to R. E. Gerton, RL, "Action Items From April 11, 1991, Meeting With the Defense Nuclear Facility Safety Board," 9105306B R2, dated December 3, 1991.

(3) WHC-SD-WM-AP-005, Rev 2, "Single-Shell Tank Leak Emergency Response Guide," dated November 1991.

Attached, please find report, WHC-SD-WM-SAD-018, Revision 1, "Safety Assessment for Interim Stabilization of Ferrocyanide Tanks." This report evaluates the safety of pumping the eight ferrocyanide tanks requiring interim stabilization. The environmental assessment, titled "Environmental Assessment for Interim Stabilization of Eight Hanford Single-Shell Tanks Containing Ferrocyanide," is also attached. These two documents complete the attached Milestone Description Sheet (MDS) 2024.

This letter also presents the recommendation for the interim stabilization of these eight ferrocyanide tanks. This recommendation completes the action in support of MDS 2001 (attached). The two assessment documents and this letter of recommendation are being submitted as one package, as promised in Reference 1.

Westinghouse Hanford Company (WHC) recommends that the eight ferrocyanide tanks be pumped until they meet the criteria for interim stabilization. This addresses Tri-Party Agreement commitments (milestone M-05-00) for minimizing future leakage to ground. The eight ferrocyanide tanks are: 241-BX-106, 241-BX-110 (listed as interim stabilized but does not meet the current criteria), 241-BX-111, 241-BY-103, 241-BY-105, 241-BY-106, 241-T-101, and 241-T-107.

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Page 2
September 30, 1992

The Safety Assessment (SA) provides the technical basis to show this can be done without presenting a hazard of airborne release from a ferrocyanide/nitrate reaction. The major points of the SA evaluation are summarized below. This rationale can also be used to justify interim stabilization of any ferrocyanide tank that is suspected of leaking in the future.

The approach taken in the SA is to show that: (1) most of the ferrocyanide tanks to be pumped are not expected to be reactive even if moisture is completely removed from the waste, (2) jet pumping will still leave the ferrocyanide sludge nearly saturated with liquor, and (3) the ferrocyanide tank sludge temperatures after pumping are not expected to show a significant long-term temperature increase.

The SA provides an evaluation of the eight tanks with respect to ferrocyanide concentration, moisture content, and expected temperature rise in the sludge. It concludes that for any of these tanks, the potential for an airborne release from a ferrocyanide/nitrate reaction as a result of jet pumping is extremely unlikely. To provide increased assurance, Tanks 241-BY-103 and 241-BY-106 can be brought within the established stabilization criteria even if pumping is stopped when the interstitial liquid level reaches the ferrocyanide sludge height.

The safety of the saltwell pumping operation for the eight tanks was evaluated in the attached SA. The physical process of interim stabilization of the ferrocyanide watchlist tanks by jet pumping is judged to be adequately bounded by the existing safety analysis and the safety study for stabilizing tanks not on a watchlist (as referenced in the SA). With the controls listed in the SA, these ferrocyanide tanks can be interim stabilized without increasing the hazard of an uncontrolled ferrocyanide-nitrate reaction.

Should jet pumping become necessary because of tank leakage, WHC would initiate the emergency pumping strategy identified in Reference 3 (currently under revision). As discussed in Reference 2, the immediate actions that would be performed, in addition to this safety document submittal, include: (1) implementation of readiness review process, (2) installation of all equipment, except in-tank equipment, and (3) upon approval to pump, installation of final equipment for pumping to established criteria. Note that this would require the acceptance of the attached safety assessment and issuance of a Finding of No Significant Impact by the U.S. Department of Energy-Headquarters and the U.S. Department of Energy, Richland Field Office (RL). Before interim stabilization can proceed, the administrative hold put on pumping in response to the Unreviewed Safety Question on criticality prevention in the waste tanks must be removed.

Mr. R. E. Gerton 9257308
Page 3
September 30, 1992

WHC expects that the SA and recommendations will undergo extensive review prior to RL authorization to proceed. WHC is prepared to support this endeavor.

If there are any questions, please contact Dr. R. J. Cash, of my staff on 3-3132 or Mr. J. M. Grigsby on 6-8907.

Very truly yours,

D. C. Richardson, Manager
Safety and Engineering

fm

Attachments 4

RL - R. F. Christensen
W. F. Hendrickson
R. O. Puthoff (w/o attachments)

WESTINGHOUSE HANFORD COMPANY

MILESTONE DESCRIPTION SHEET

1A.b
~~SAFE 10/~~2001
Rev. 2

Title: Submit Recommendations on Capability to Stabilize FeCN Tanks in Support of the TPA

Date: 11/08/91

Assigned To: Waste Management Technology

CIN: 9850-1W

Program WBS Designator: 1N2C31

Completion Date: 6/30/92

Revision: 2

Milestone Class:	Deliverable:	Addressed To:
[ ] TPA	[X] Report	[ ] DOE-HQ
[ ] DOE-HQ	[X] Letter	[X] DOE-RL
[X] DOE-RL	[ ] Drawings	[ ] Other (Specify)
[ ] WHC Key	[ ] Other (Specify)	

Description and what constitutes completion of this milestone:

Deliverables: Due Date:

1. Transmittal of a letter to the RL Project Manager, Tank Farm Project Office, documenting the capability and recommendation to stabilize FeCN tanks to support TPA requirements. — 6/30/92

Performance Criteria:

Excellence:

Very Good:

Satisfactory:

R. J. Cash 11-21-91
COST ACCOUNT MANAGER DATE

G. T. Dukelow 11/21/91
ACTIVITY MANAGER DATE

J. L. Deichman 11/21/91
PROGRAM MANAGER DATE

R. F. Christensen 12/3/91
DOE MONITOR DATE

TFPO approval for deliverables and milestone dates only--not Performance Criteria.

WESTINGHOUSE HANFORD COMPANY

MILESTONE DESCRIPTION SHEET

1A.b
~~SAFE 11/~~2024
Rev. 2

Title: Complete Safety Assessment and Limited Risk Assessment for Pumping FeCN Tanks (Emergency Action or Interim Stabilization

Date: 11/08/91

Assigned To: Waste Tank Safety Analysis

CIN: ADS ID 9850-1W

Program WBS Designator: 1N2C31

Completion Date: 5/29/92

Revision: 2

Milestone Class:
[ ] TPA
[ ] DOE-HQ
[ ] DOE-RL
[X] WHC Key

Deliverable:
[X] Report
[X] Letter
[ ] Drawings
[ ] Other (Specify)

Addressed To:
[ ] DOE-HQ
[X] DOE-RL
[ ] Other (Specify)

Description and what constitutes completion of this milestone:

Deliverables:	Due Date:
1. Transmittal of a letter to the RL Project Manager, Tank Farm Project Office, documenting the conduct of appropriate reviews and limited risk assessment of the capability to pump FeCN tanks in case of an emergency or to support interim stabilization requirements of the TPA.	5/29/92

Performance Criteria:

Excellence:

Very Good:

Satisfactory:

R. J. Cash [signature] 11-21-91
COST ACCOUNT MANAGER DATE

J. L. Deichman [signature] 11/21/91
PROGRAM MANAGER DATE

G. T. Dukelow [signature] 11/2/91
ACTIVITY MANAGER DATE

N/A
DOE MONITOR DATE

Date Received: 9-30-92

INFORMATION RELEASE REQUEST

Reference: WHC-CM-3-4

Complete for all Types of Release

Purpose

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- [] Full Paper
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[X] Technical Report
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[] Manual
[] Brochure/Flier
[] Software/Database
[] Controlled Document
[] Other

ID Number (include revision, volume, etc.): WHC-SD-WM-SAD-018 Rev. 0

List attachments.

Date Release Required: September 29, 1992

Title: Safety Assessment for Interim Stabilization of Ferrocyanide Tanks

Unclassified Category: UC-

Impact Level: ESQ

New or novel (patentable) subject matter? [X] No [] Yes
If "Yes", has disclosure been submitted by WHC or other company?
[] No [] Yes Disclosure No(s).

Information received from others in confidence, such as proprietary data, trade secrets, and/or inventions?
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Review Required per WHC-CM-3-4	Yes	No	Reviewer - Signature Indicates Approval: Name (printed)	Signature	Date
Classification/Unclassified Controlled Nuclear Information	[]	[X]			
Patent - General Counsel	[]	[X]			
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WHC Program/Project	[]	[X]			
Communications	[]	[X]			
RL Program/Project	[]	[X]			
Publication Services	[]	[X]			
Other Program/Project	[]	[X]			

Information conforms to all applicable requirements. The above information is certified to be correct.

	Yes	No
References Available to Intended Audience	[X]	[]
Transmit to DOE-HQ/Office of Scientific and Technical Information	[]	[X]

Author/Requestor (Printed/Signature) Date
M. Kummerer Maryanne Kummerer 9/23/92

Intended Audience
[] Internal [X] Sponsor [] External

Responsible Manager (Printed/Signature) Date
J. M. Grigsby 9/23/92

INFORMATION RELEASE ADMINISTRATION APPROVAL STAMP

Stamp is required before release. Release is contingent upon resolution of mandatory comments.

Date Cancelled

Date Disapproved

BD-7600-062 (08/91) WEF074

Part 1

WHC-SD-WM-SAD-018 Rev. 0
ID Number

Lead Author	Phone	MSIN	Other Author(s) or Requestor
M. Kummerer	6-2520	H5-31	R. D. Crowe
Project or Program: Waste Remediation Safety Programs	Lead Org Code: 29120		Sponsor Agency (DOE, DOT, NRC, USGS, etc.): DOE
Editor: C. S. Krogness	Phone: 6-2689	MSIN: L6-10	DOE/HQ Program (DP, EH, EM, NE, etc.)

Mandatory Comments (Only mandatory comments are to be documented. All other comments should be made on a copy of the information submitted for review and returned to the author.)	Reviewer Name & Signature	Date	Resolution	Reviewer Name & Signature	Date

Legends/Notices/Markings (required per WHC-CM-3-4 or guidance organization.) (Reviewer initials)

	Affix Yes	Affix No
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Responsible Manager (Printed/Signature)

Additional Information

BD-7600-062 (08/91) WEF074

Part 2

SEP 30 1992 (11)

Station #21

ENGINEERING DATA TRANSMITTAL

Page 1 of 2

1. EDT 160467

2. To: (Receiving Organization)	3. From: (Originating Organization)	4. Related EDT No.:
Waste Remediation Safety Programs	Waste Tank Safety Analysis	
5. Proj./Prog./Dept./Div.:	6. Cog. Engr.: M. Kummerer	7. Purchase Order No.:

8. Originator Remarks: Transmitted for review and approval.

9. Equip./Component No.:

10. System/Bldg./Facility:

11. Receiver Remarks:

12. Major Assm. Dwg. No.:

13. Permit/Permit Application No.:

14. Required Response Date: 9/8/92

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Impact Level	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-WM-SAD-018		0	Safety Assessment for Interim Stabilization of Ferrocyanide Tanks	2ESQ	1,4	1	1

16. KEY

Impact Level (F)	Reason for Transmittal (G)	Disposition (H) & (I)
1, 2, 3, or 4 (see MRP 5.43)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Impact Level for required signatures)

(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN	(J) Name (K) Signature (L) Date (M) MSIN	(G) Reason	(H) Disp.
1	1	Cog.Eng. M. Kummerer H5-32	R. D. Crowe 9/25/92 H5-32	1	1
1	1	Cog. Mgr. J. M. Grigsby H5-32	V. C. Boyles R1-49	4	
1	1	QA For D. C. Board 9/28/92 S1-57	S. M. Stahl H5-31	4	
1	1	Safety M. N. Islam 9/22/92 R3-08	R.J.Cash 9/25/92 R2-32	1	1
1	1	Env. L. P. Diediker 9-25-92 T1-30	R.E.Raymond R1-30	1	1
1	1	G. M. Christensen 9/28/92 H4-21	TFO Subcouncil Chairman RMM	1	
4		G. L. Borsheim R2-11	See page 2 for signature		

18.	19.	20.	21. DOE APPROVAL (if required)
M. Kummerer 9/29/92 Signature of EDT Originator Date	R. J. Cash 9/29/92 Authorized Representative Date for Receiving Organization	J. M. Grigsby 9/29/92 Cognizant/Project Date Engineer's Manager	Ltr. No. [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (07/91) GEF097

BD-7400-172-1 (07/91)

09/30/92 09:45 ☎509 372 0065 DEF. WASTE REM. --- WASTE REM SAF PR 002

09/30/92 09:22 ☎509 376 3446 WASTE REM SAF PR --- DEF. WASTE REM. 002

SEP 30 1992 (11)
Station #21

ENGINEERING DATA TRANSMITTAL

Page 2 of 2
1. EDT 160467

2. To: (Receiving Organization) Waste Remediation Safety Programs	3. From: (Originating Organization) Waste Tank Safety Analysis	4. Related EDT No.:
5. Proj./Prog./Dept./Div.:	6. Cog. Engr.: M. Kummerer	7. Purchase Order No.:
8. Originator Remarks: Transmitted for review and approval.		9. Equip./Component No.:
		10. System/Bldg./Facility:
11. Receiver Remarks:		12. Major Assm. Dwg. No.:
		13. Permit/Permit Application No.:
		14. Required Response Date: 9/8/92

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Impact Level	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-WM-SAD-018		0	Safety Assessment for Interim Stabilization of Ferrocyanide Tanks	2ES Q	1,4	1	1

16. KEY

Impact Level (F)	Reason for Transmittal (G)	Disposition (H) & (I)
1, 2, 3, or 4 (see MRP 5.43)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Impact Level for required signatures)

(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.
1	/	Cog. Eng. M. Kummerer	[signature]		H5-32	R. D. Crowe	[signature]	9/26/92	H5-32	1	/
1	/	Cog. Mgr. J. M. Grigsby	[signature]		H5-32	V. C. Boyles			R1-49	4	
1	/	QA D. C. Board	[signature]	9/28/92	S1-57	S. M. Stahl			H5-31	4	
1	/	Safety M. N. Islam	[signature]	9/29/92		R.J.Cash	[signature]	9/29/92	R2-32	/	/
1	/	Env. L. P. Diediker	[signature]	9/25/92	T1-30	R.E.Raymond	[signature]		R1-80	/	/
1	/	G. W. Christensen	[signature]	9/25/92	H4-21	TFO Subcouncil Chairman	[signature]	9/30/92			/
4		G. E. Borsheim			R2-11						

18.	19.	20.	21. DOE APPROVAL (if required)
M. Kummerer [signature] 9/29/92 Signature of EDT Originator / Date	R. J. Cash [signature] 9/29/92 Authorized Representative for Receiving Organization / Date	M. Grigsby [signature] 9/29/92 Cognizant/Project Engineer's Manager / Date	Ltr. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments

BD-7400-172-2 (07/91) GEF097

SUPPORTING DOCUMENT

SUPPORTING DOCUMENT		1. Total Pages 34
2. Title Safety Assessment for Interim Stabilization of Ferrocyanide Tanks	3. Number WHC-SD-WM-SAD-018	4. Rev No. 0
5. Key Words Single Shell Tanks, Ferrocyanide, Safety Assessment, Interim Stabilization, Saltwell Jet Pumping	6. Author Name: M. Kummerer R. D. Crowe Signature Organization/Charge Code 29120/N231P	

7. Abstract

This safety assessment examines the existing safety analysis of interim stabilization of single shell tanks, and discusses additional potential hazards arising from the reactive nature of the waste components in ferrocyanide tanks.

9. Impact Level 2ESQ

10. RELEASE STAMP

A-6400-073 (11/91) (EF) WEF124

WHC-SD-WM-SAD-018 REV 0

CONTENTS

LIST OF FIGURES

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LIST OF TERMS

(CN^-)	cyanide ion
CTMS	continuous temperature monitoring system
DCRT	double-contained receiver tanks
EDE	effective dose equivalent
FIC	Food Instrument Corporation
HEPA	high-efficiency particulate air
JCO	justification for continued operation
LFL	lower flammability limit
LOW	liquid observation wells
MLD	master logic diagram
SST	single shell tanks
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
USQ	Unreviewed Safety Question
WHC	Westinghouse Hanford Company

WHC-SD-WM-SAD-018 REV 0

SAFETY ASSESSMENT FOR INTERIM STABILIZATION OF FERROCYANIDE TANKS

1.0 SCOPE

This safety assessment addresses interim stabilization of eight Hanford Site single-shell tanks (SSTs) that are on record as containing greater than 1,000 mol of ferrocyanide. The eight ferrocyanide tanks that require interim stabilization are BX-106, BX-110, BX-111, BY-103, BY-105, BY-106, T-101, and T-107.

1.1 PURPOSE OF SAFETY ASSESSMENT

In the interest of reducing the amount of radioactive liquids available for release to the environment from potential tank leaks, Westinghouse Hanford Company (WHC) is pursuing a program for interim stabilization and isolation of all Hanford Site SSTs. A tank is considered to be interim stabilized if it contains less than 5,000 gal of supernate and less than 50,000 gal of drainable interstitial liquid associated with the waste solids. In addition, if a tank is jet pumped, the pumping flow rate has to be below 0.05 gal/min before pumping is complete (Hanlon 1992). Isolation of the tanks involves closing off all pathways by which additional wastes could be introduced to the tanks.

Supernates are typically removed by a submersible pump. Removal of the interstitial liquid contained in the waste solids is achieved by a process called salt well jet pumping. The residual liquid left in the tank after this process is largely held in the solids by physical and chemical forces. Therefore, the amounts available to drain through a breach in the tank below the remaining liquid level would be very small.

In 1990, WHC declared an Unreviewed Safety Question (USQ) with respect to tanks containing significant amounts of ferrocyanide because the analyzed safety envelope in the facility safety analysis reports did not show that potential accidents involving the tanks' contents had been bounded. A watchlist was established to include 24 tanks that, at the time, were thought to contain at least 1,000 mol of ferrocyanide. Because an USQ exists for these tanks, any activity that involves opening the confinement boundaries of the tanks is restricted until the safety of the activity has been thoroughly examined. Pumping to achieve interim stabilization is such an activity.

Commitments under the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) (Ecology 1989) require that all 149 SSTs be interim stabilized by September 1996. To date, 105 of the 149 SSTs have been interim stabilized. The process is nearly completed for an additional five tanks. Of the 24 tanks on the ferrocyanide watchlist, 17 were either interim stabilized by salt well jet pumping before the USQ was declared or were judged to contain too little free liquid to require pumping (administratively stabilized). To meet the Tri-Party Agreement commitment, the safety of interim stabilizing the remaining 8 ferrocyanide tanks must be established.

Aside from the committed schedule discussed above, WHC must be prepared to commence pumping a tank as soon as safely possible after it has been identified as an assumed leaker. The *Single-Shell Tank Leak Emergency Response Guide* (Lo 1991) outlines actions to be taken. For a tank that is on the watchlist, pumping preparations would be made. Work in the tank, including the pumping operations, would require a readiness review. For a tank involving a USQ, the readiness review requirements would include a safety assessment. This document fulfills that requirement for the eight subject ferrocyanide tanks.

An additional USQ has been declared with respect to the risk from nuclear criticality for the tanks. The justification for continued operation (JCO) in response to that USQ placed an administrative hold on pumping of liquid waste from the SSTs to accomplish interim stabilization (Gerton 1992). It requires that the effect of removing supernatant moderator be evaluated and, if necessary, that administrative and operational controls to minimize risk and ensure the safety of these operations be established. Therefore, pumping of the ferrocyanide tanks will not proceed until that evaluation is completed.

Alternatives to interim stabilization by salt well jet pumping have been proposed. The "no action" option, which would permit the SSTs to leak their contents to the ground, is unacceptable in light of existing commitments to prevent further contamination of Hanford Site soils. Furthermore, the moisture content of ferrocyanide waste is an important consideration for continued safe storage. Loss of liquid through a tank leak is expected to have a similar effect on the waste stability as interim stabilization by jet pumping. However, the loss by leakage would be uncontrolled.

Other alternatives to salt well jet pumping are: (1) engineered barriers around the tanks to fix or confine the leaking wastes in a limited volume of soil and (2) in-tank solidification of the wastes by processes such as glassification. The extent of technology development necessary to realize either of these options prevents their usefulness for the near-term minimization of releases to the environment. They have not been ruled out as long-term options, however.

1.2 BACKGROUND OF FERROCYANIDE TANKS

Ferrocyanide ion and nickel additions were used in early waste reduction campaigns at the Hanford Site to precipitate radioactive cesium (as cesium nickel ferrocyanide) from waste solutions so that low-activity supernate could be removed. The process used also included the means to remove radioactive strontium from the waste streams.

The ferrocyanide precipitate in the tanks is primarily disodium nickel ferrocyanide [$Na_2NiFe(CN)_6$]. It is diluted with the other solids that were also brought down when the solution was made alkaline to precipitate the ferrocyanide, notably iron hydroxide, strontium phosphate, and sodium salts of phosphate, sulfate, and nitrate.

The recipe for the precipitation process varied slightly for different campaigns. However, the sludges fall roughly into three categories: U Plant, T Plant, and In-Farm. Of these, the In-Farm waste is significantly more concentrated in ferrocyanide than the other two because the treated waste had previously been in an alkaline state and had lost most of the other components that serve to dilute the other wastes. The tanks that are the subject of this safety assessment all contain wastes from the U Plant process.

Subsequent to the ferrocyanide campaigns, other wastes were added to some of the tanks. Later additions to some of the tanks were in the form of supersaturated, partially crystallized, alkaline solutions remaining from waste concentration, another waste reduction process. These solutions also contained alkaline insoluble hydroxides and hydrated oxides produced when the acidic waste solutions were made alkaline for storage in the carbon steel-lined tanks. The hot concentrated waste was pumped on top of the ferrocyanide sludge layer. As it cooled the crystals settled making a cake of salt saturated with mother liquor.

To obtain more information about the expected composition and behavior of the ferrocyanide tank contents, laboratory scale tests have been performed using nonradioactive simulants made up from the original process flowsheets. Tests to determine the energetics of the ferrocyanide salts in the presence of nitrate oxidant were completed (Bechtold 1992 and Fauske 1992). Other tests to investigate the hydraulic properties of the sludge have been performed (Wong 1992). In addition to the testing of waste simulants, samples from one tank, C-112, have been tested.

1.3 FERROCYANIDE TANKS REQUIRING INTERIM STABILIZATION

Of the 24 ferrocyanide watchlist tanks, 17 had been interim stabilized, either by administrative review or by pumping, before the USQ was declared. Seven tanks remain that do not meet interim stabilization criteria. They are BX-106, BX-111, BY-103, BY-105, BY-106, T-101, and T-107. One additional tank, BX-110, was jet pumped in 1985 and declared interim stabilized. However, further pumping may be required because calculation of remaining drainable liquid may not have been correct. The tank has no liquid observation well (LOW) for monitoring the interstitial liquid level. Therefore, Tank BX-110 is included in the scope of this safety assessment.

After the ferrocyanide watchlist was established, an investigation was conducted into the records of the ferrocyanide campaigns (Borsheim 1991). It revealed that the inventory data used to assign tanks to the watchlist was very likely to be in error for many of the 24 tanks.

On the basis of that investigation, it is now thought that BX-106, BX-110, BX-111, and T-101 do not contain the requisite amount of ferrocyanide and, therefore, should not be on the ferrocyanide watchlist. However, since they have not yet been formally removed from the list, they are included in this safety assessment with the assumption that they contain at least 1,000 mol of ferrocyanide.

Each of the tanks, except BX-106, has a salt well screen already installed. Tank BX-106 contains a few feet of solid waste with 15,000 gal of supernate. Stabilization criteria can be met with supernate pumping only. Therefore, jet pumping of that tank is not required.

Results of chemical analysis of supernate samples from the BX and BY tanks examined in this safety assessment are available. They are summarized in Table 1.

Table 1. Analysis of BX and BY Tank Supernate Samples.*

Tank	Specific gravity	pH	H_2O (%)	TOC (g/L)	CN^- (µg/g)	NO_3^- (M)	^{90}Sr (µCi/L)	^{137}Cs (µCi/L)
BX-106	1.33	13.28	63.8	4.4	NA	2.62	5.16 E+02	1.81 E+05
BX-110	1.37	12.5	56.6	5.6	NA	5.04	1.50 E+01	1.35 E+05
BX-111	1.44	12.7	53.3	5.7	NA	2.62	2.00 E+01	2.60 E+05
BY-103	1.45	13.29	52.0	2.73	6.73	4.37	2.33 E+02	2.00 E+05
BY-105	1.39	13.24	54.3	2.93	14.57	8.42	1.30 E+01	7.40 E+04
BY-106	1.46	13.47	49.6	3.16	45.38	4.05	1.20 E+02	3.11 E+05

*Data reproduced from Grigsby 1992.
NA = not available.
TOC = total organic carbon.

2.0 DESCRIPTION OF ACTION

2.1 GENERAL INFORMATION

The WHC Waste Stabilization and Isolation Program requires the removal of supernate and drainable interstitial liquid from solid wastes in SSTs. This is accomplished by salt well pumping using jet pumps. The pumped liquid waste is transferred to double-contained receiver tanks (DCRT) at low pumping rates. The liquid accumulated in the DCRT is eventually transferred to double-shell storage tanks or is sent into the waste concentration system for volume reduction. Figure 1 provides a simplified representation of a typical Salt Well-DCRT System.

2.2 SYSTEM INFORMATION

In general, the process facilities and equipment needed for the interim stabilization by salt well jet pumping of the SSTs are:

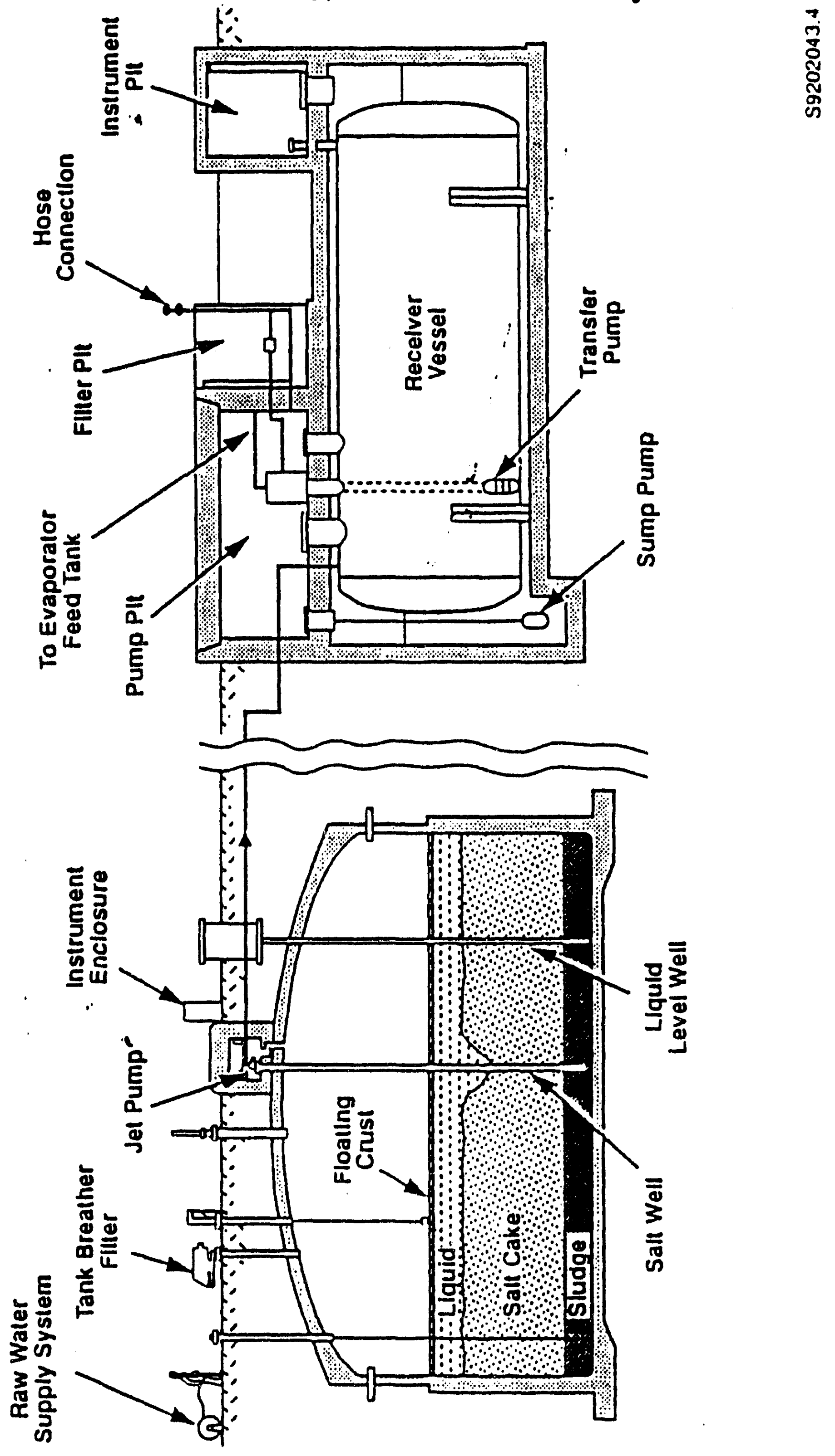
1. Single-shell waste storage tank

2. Pump pit, salt well screen, jet pump assembly, and jet pump jumper assembly

3. Transfer piping and valve pits

4. Double-contained receiver tanks

Figure 1. Typical Salt Well-DCRT System.



5. Associated instrumentation, alarms, and controls

6. Double-shell waste storage tank.

2.2.1 Single-Shell Waste Storage Tanks

The underground single-shell waste tanks considered in this safety assessment are two sizes. Tanks in the BX and T Tank Farms have a nominal capacity of 530,000 gal, while the capacity of the BY Tank Farms is 750,000 gal. The tanks are constructed of reinforced concrete with a mild steel liner covering the bottom and sidewalls. Figure 2 shows a schematic of these two types of tanks.

All of the SSTs have been inactive since 1980. Therefore, no waste transfers into the tanks included in this safety assessment have been made since that time, and none are planned for the future. All the subject tanks are passively ventilated through a riser with high-efficiency particulate air (HEPA) filtration.

Temperature readings from thermocouples at various depths in the waste are taken and recorded manually once a week. In the BY Farm, tank thermocouples are also connected to a continuous temperature monitoring system (CTMS). Temperatures are recorded every 15 minutes.

Various level measuring techniques are used to monitor total waste and interstitial liquid levels. Tanks BY-103, BY-105, BY-106, and BX-111 have LOW in which a combination of neutron and gamma ray scanning is used to determine interstitial liquid level. The waste level in these four tanks is taken manually by tape. Tank BX-110 has no LOW and the waste level in this tank is also read manually from tape. The other three tanks are equipped with Food Instrument Corporation (FIC) level gauges. In Tank BX-106 the level readings are taken manually. In tanks T-101 and T-107, the FIC gauge readings are transmitted to an automatic data recording system.

2.2.2 Salt Well and Jet Pump

The equipment and installations required at the SST for jet pumping from the salt well are: (1) a pump pit, (2) a salt well screen, (3) a jet pump assembly consisting of a centrifugal pump and jet assembly, (4) jet pump jumpers, and (5) associated instrumentation and controls.

The dome of each SST is penetrated by several risers, one of which protrudes into a pump pit. A pump pit is a concrete structure located above the tank dome near the center of the tank. The jet pump system is housed within the pump pit with portions of it extending down into the riser. Figure 3 shows a typical salt well jet pump system.

The salt well jet pump system includes an 8- or 10-in.-diameter salt well casing consisting of a salt well screen welded to schedule 40 carbon steel pipe. The casing and screen are inserted into a 12-in. tank riser located in the pump pit. They extend through the tank waste to near the bottom of the tank.

Figure 2. High-Level Waste Tank Configuration.

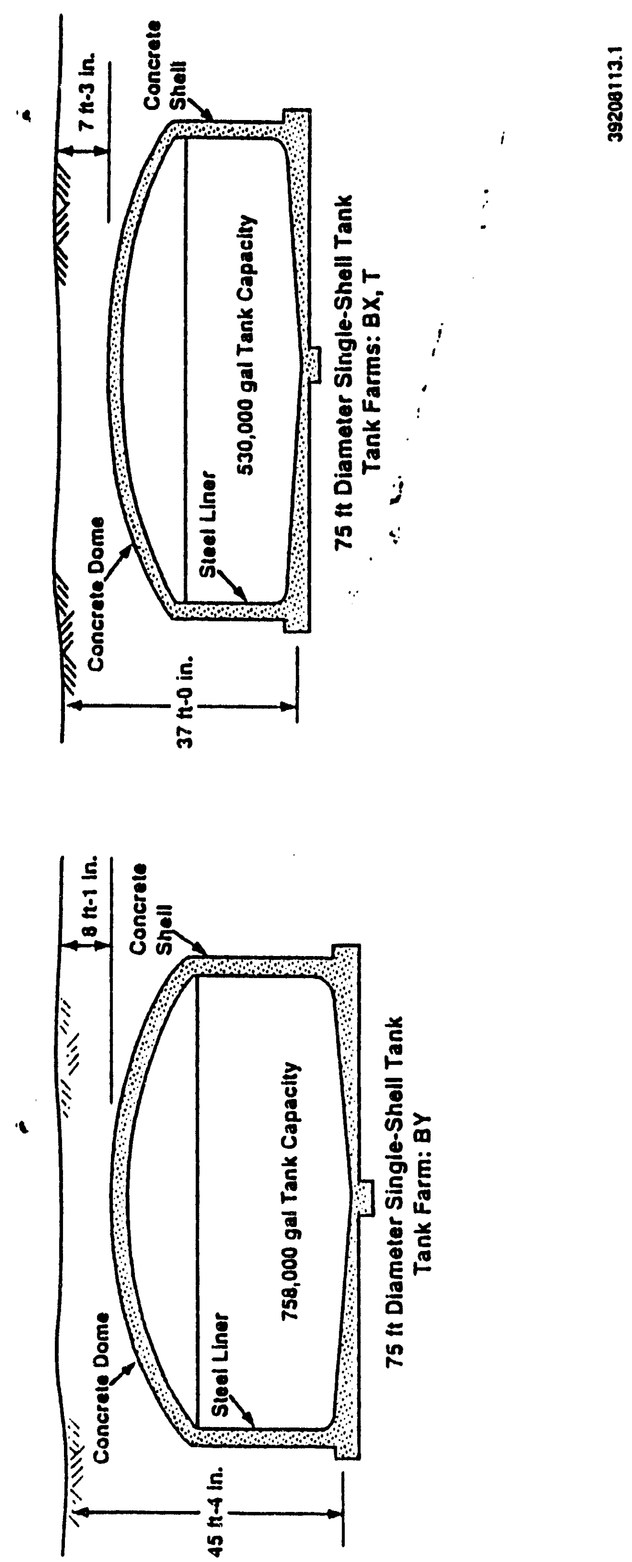
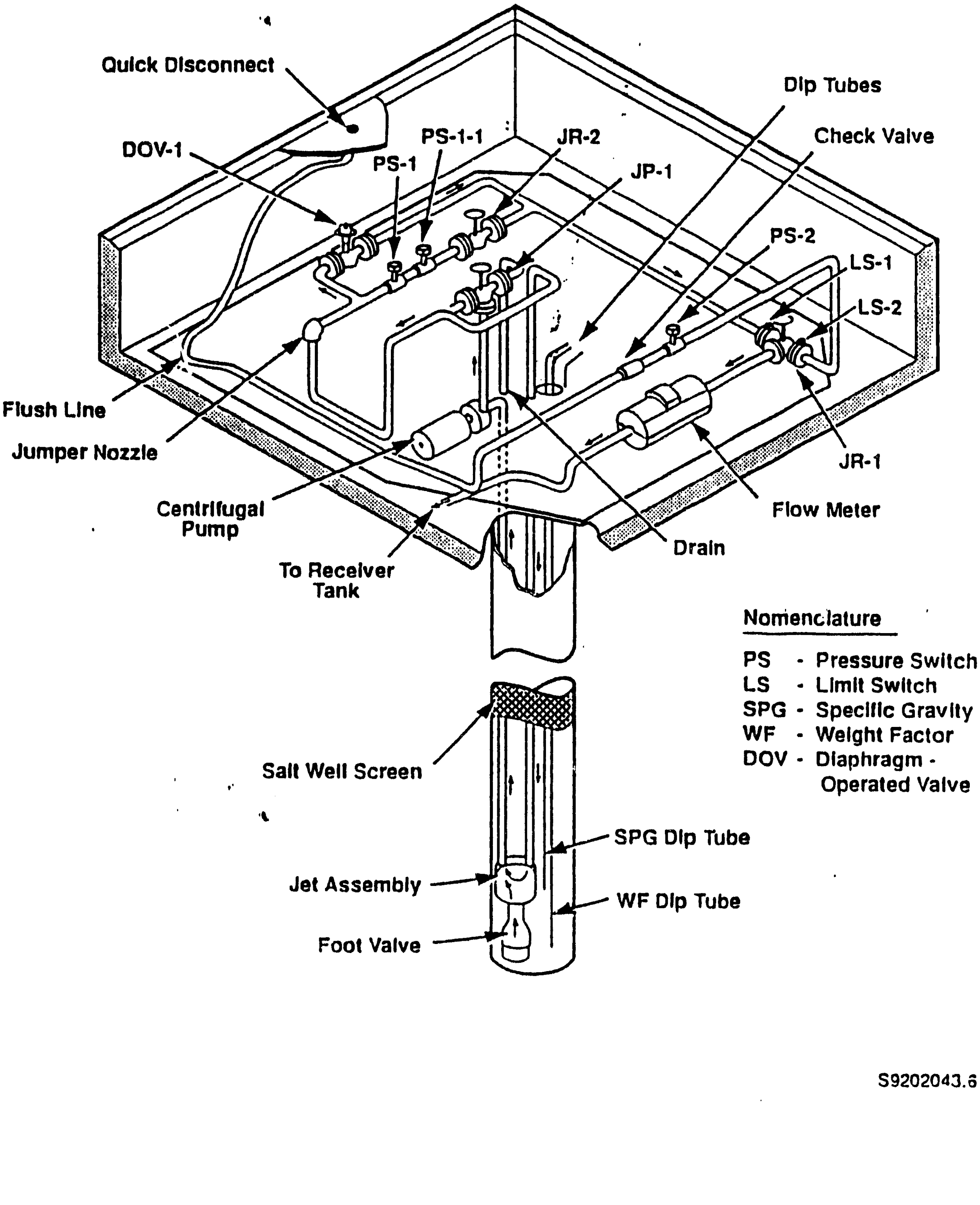


Figure 3. Typical Salt Well Jet Pump.



The salt well screen consists of a length of 300-series, 8- to 10-in.-diameter stainless steel pipe with screen openings (slots) of 0.05 in. A jet assembly with foot valve is mounted to the base of two pipes that extend from the top of the well to near the bottom of the well casing inside the salt well screen. The salt well screen also holds dip tubes for measuring specific gravity and weight factor of the liquid. All of the tanks included in this safety assessment have salt well screens installed except for Tank BX-106 (Lo 1991). Since interim stabilization could be accomplished in that tank by pumping off the 15,000 gal of supernate, salt well pumping may not be required.

The components of the jet pump system located within the pump pit include a centrifugal pump to supply power fluid to the down-hole jet assembly, flexible or rigid jumpers, a flush line, and a flowmeter. The jumpers contain piping, valves, and pressure and limit switches. Instrumentation and control devices are also located within the pump pit. A drain in the bottom of the pump pit empties into the tank and is normally open.

The centrifugal pump and jet assembly are needed to raise the interstitial liquid from the salt well screen into the pump pit, nominally a 40-ft elevation rise. The centrifugal pump, rated at approximately 30 gal/minute at 30 psig, pressurizes power fluid to the jet assembly located in the salt well screen. The power fluid passes through a nozzle in the jet assembly and acts to convert fluid pressure head to velocity head, thereby reducing the pressure in the jet assembly chamber. The reduction in pressure allows the interstitial liquid to enter the jet assembly chamber and mix with the power fluid. Velocity head is converted to pressure head above the nozzle, lifting power fluid and interstitial liquid to the pump pit. Pumping rates vary from 0.05 gal to about 4 gal/minute.

Raw water is used to fill the salt well jet pump system loop and prime the pump for operation. A recirculation loop permits the prime on the pump to be maintained at very low pumping rates. The energy produced by the pump's operation can heat the recirculated liquid about 30 °F above tank temperatures.

Important instrument and control systems at the tank associated with salt well pumping include: (1) leak detection; (2) jet pump system controls, including limit switches and safety interlocks; and (3) weight factor and specific gravity measurement.

Leak detection is provided in each pump pit in the salt well system. Leak detection in a single pit is interlocked to shut down the pump in that pit as well as all pumps on the same manifold. A flashing light and an audible alarm, located on top of the pump control station outside the pump pit area, alert tank farm operators to the shutdown condition.

Up to four salt well pumps are connected by manifold to a common waste transfer line. The pumps are interlocked to provide safe and orderly shutdown of the group in the case of an unplanned event. The interlocks that shut down the pumps include: (1) loss of pump outlet pressure, (2) excess pressure in the flush leg, (3) high pressure in the circulation loop, (4) leak detection in the pump pit, (5) area radiation detection, (6) leak detection in a DCRT, and (7) DCRT at maximum operating level.

Dip tubes, extending into the liquid waste through the salt well casing, are used to measure the weight factor and specific gravity. From these measurements the liquid level in the salt well screen is determined. Controllers are set to control the liquid level a fixed amount above the jet intake.

2.2.3 Transfer Piping and Valve Pits

Transfer lines designated for transfer of waste from the BX, BY, and T Tank Farms to the double contained receiver tanks are direct buried lines with 3 ft of ground cover to provide shielding. These lines are carbon steel welded pipe, 1 to 3 in. in diameter. All transfer lines are sloped for drainage.

The design life of all salt well pumping transfer lines is five years. They are now more than 10 years old. Therefore, the lines must be pressure tested before use and every six months during use to ensure against leaks. The requirement is that the lines must have been tested within the six-month period prior to their use. Procedure TO-140-170 (WHC 1990) describes the method of pressure testing.

Flow from the tanks to the receiver tank is routed through a valve pit. There the flow from the sending tanks' transfer lines is routed through a manifold to the receiving tank line by a series of valves and jumper connections. Two- and three-way valves are built into each jumper to divert the flow where needed. Valve pits are concrete boxes with heavy cover blocks. Leak detection in the valve pit is interlocked with corresponding pumps. A drain line in the valve pit connects to a flush pit.

2.2.4 Double-Contained Receiver Tanks

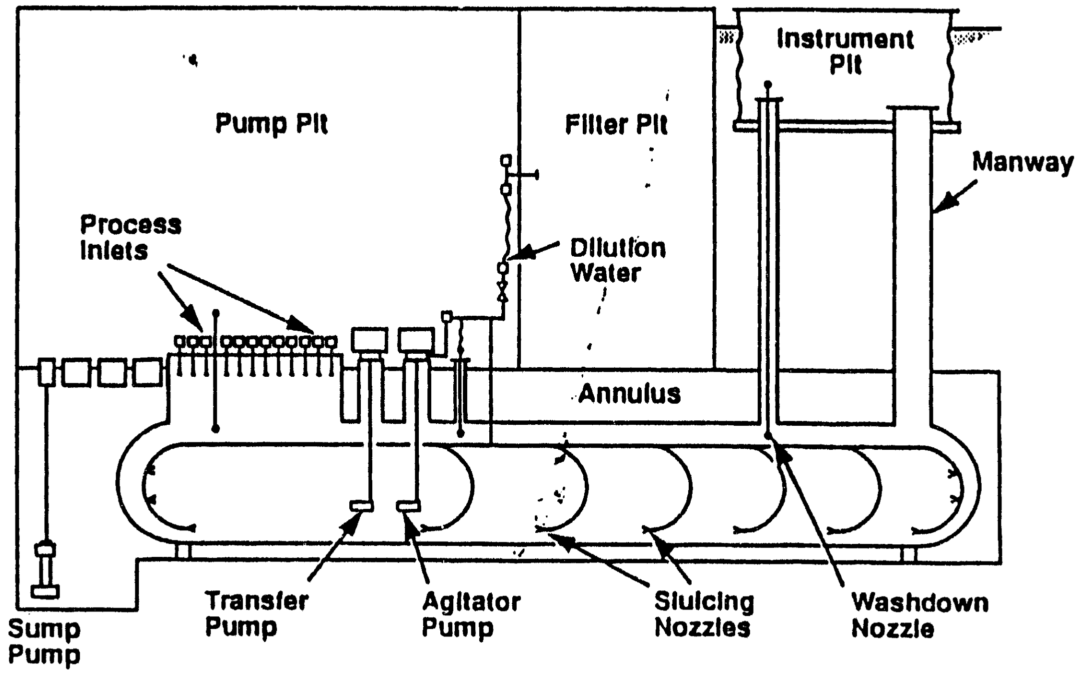
Salt well waste from the BX and BY tank farms will be accumulated in DCRT BX-244. The salt well waste from the T Tank Farms will go to the TX-244 DCRT.

The BX-244 and TX-244 DCRTs are 25,000-gal cylindrical tanks. The tank is positioned with its axis horizontal in the lower section of a reinforced concrete vault. Above the tank vault, and connected to it, are a pump pit and a filter pit. An instrument enclosure is also above the tank vault but not connected to it.

The pump pit contains transfer and agitator pumps and jumper connections to the transfer lines and valves. The filter pit contains a ventilation system equipped with HEPA filters. The tank vault contains the receiver tank and a sump well. Associated instrumentation is contained in the instrumentation pit. Figure 4 shows the typical arrangement of the receiver vessel in its vault.

The ventilation system maintains the receiver vessel and annulus under negative pressure with respect to the atmosphere to prevent the release of radioactive materials in case of a tank breach. Supply air is taken into the

Figure 4. Receiver Vessel, Typical Configuration.



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tank annulus through a roughing filter and a HEPA filter. The exhaust system pulls air from the annulus and the inner tank through a roughing filter and two stages of HEPA filters.

Safety considerations and controls on the ventilation systems provide dampers and valves for regulation/isolation, measurement of differential pressure across the filters, continuous radioactive particulate monitoring and record sampling of exhaust air, and continuous flow measurement of exhaust air.

Leak detectors in DCRT sumps are interlocked with the primary pumps to shut down in the event of a leak in the DCRT. Leak detectors are also installed in the filter pits.

To minimize the precipitation of solids from liquor in the piping systems, the capability of water dilution is provided in the DCRTs. In TX-244, rotating spray nozzles are installed inside the tank to aid in tank flushing. Also, sluice jets and flow from a pump agitator provide a means to resuspend solids.

3.0 IDENTIFICATION OF HAZARDS

A complete assessment of the safety of interim stabilizing the ferrocyanide tanks must examine two different sets of potential hazards:

- The hazards that could result from the change in tank contents because of interim stabilization, especially the removal of significant liquid volumes
- The hazards presented during the activities involved in the interim stabilization process (e.g., jet pumping, transfer to a DCRT).

This safety assessment examines the state of the tanks' contents after significant volumes of liquid are removed by interim stabilization. The effect of reducing the total amount of moisture in the tank on the potential reactivity of the ferrocyanide-bearing portion of the tank is examined.

Safety analysis of the interim stabilization process for SSTs, in general, is documented in various safety analysis reports (Hanson 1980 and Hanson 1981). In addition, a safety study to evaluate the adequacy of the existing safety envelope for the interim stabilization of eleven tanks not on a watchlist has been conducted (Stahl 1992a). That safety study included an independent identification of the hazards of salt well jet pumping activities for SSTs in general and identified some hazards that warranted additional analysis.

Since the potential hazards identified in those documents were judged to encompass the hazards of pumping ferrocyanide tanks, no new hazards identification was performed for this safety assessment. The potential hazards were examined to determine whether additional risks could exist because of the characteristics of the ferrocyanide tanks' contents.

3.1 POSTSTABILIZATION STORAGE HAZARDS

The hazard of concern for continued storage of the waste in the ferrocyanide tanks after interim stabilization is release of radioactive material during a pressurization of the tank caused by an energetic reaction of some of the tanks' contents. Assessing the safety of storage after stabilization requires determining whether removing significant volumes of tank liquor induces changes in the tanks' contents that make the conditions for energetic reaction more likely.

3.1.1. Ferrocyanide Reactions

The master logic diagram used for hazards assessment of interim stabilization (Coles 1992) identifies three conditions that must be simultaneously present for a release caused by a ferrocyanide/nitrate explosion to occur. They are as follows:

- Ferrocyanide and oxidant must exist in sufficient concentrations to be reactive

- Moisture associated with the ferrocyanide sludge must be insufficient to quench a reaction
- The energy balance of the reactive region must be such that temperatures high enough to initiate a reaction can be reached.

A discussion of the margins for safe storage with respect to each of these conditions follows. The effect interim stabilization is expected to have on each of these three conditions is discussed in Section 4.

3.1.1.1 **Ferrocyanide/Nitrate Content.** Ferrocyanide can be oxidized by nitrate in reactions that give off energy. The ferrocyanide sludges are known to contain excess nitrate. Under the proper conditions, this combination can react energetically. Of concern for the storage of wastes is the potential for a propagating reaction; that is, one that, once initiated, could release enough energy to heat the surrounding material to its ignition temperature. Tests on oxidant rich mixtures of ferrocyanide and nitrate/nitrite have placed the onset temperature of an energetic propagating reaction at about 285 °C (540 °F).

Based on the results of these analyses, the theoretical range of combinations of ferrocyanide and nitrate oxidant, water and other inert compounds for which a propagating reaction is thermodynamically possible was calculated (Grigsby 1992). The results show that for mixtures with stoichiometric ferrocyanide/nitrate mixtures (1 mol ferrocyanide:6 mol $NaNO_3$) less than 9 wt% of the total, a propagating reaction will not occur. This is taken as a conservative bound for safe storage.

Testing of waste simulants indicates that propagating reactions do not occur until higher ferrocyanide concentrations than those indicated by theoretical model are reached (Fauske 1992). Preliminary results of thermal testing of actual waste from Tank C-112 showed very little exothermic activity. Tank C-112 sludge is expected to contain a higher ferrocyanide concentration than the tanks addressed in this safety assessment, because it was formed by the process (In-Farm) that resulted in highest ferrocyanide concentrations. Therefore, using the results of the theoretical model to bound safe concentration is conservative.

Because the exact quantities and distribution of the ferrocyanide in the tanks are considered uncertain, a factor of safety of 3 is applied to the assumed maximum tank concentrations. Use of this factor acknowledges that uneven vertical distribution of the ferrocyanide through the sludge layer may exist. The factor of three was chosen because it is known that, for U Plant campaigns, the ferrocyanide added to the various batches was either 0.0025 mol or 0.005 mol. Allowing for the presence of more or less other precipitates that contribute to the volumes of the settled sludge and for variances in the settling characteristics of different batches a factor greater than two was chosen.

Therefore, if three times the mass of stoichiometric ferrocyanide/nitrate is less than 9% the mass of the sludge, the tank is considered safe for storage from the perspective of ferrocyanide reactivity. This is equivalent to all the ferrocyanide being concentrated in 1/3 of the sludge volume along with enough nitrate to allow it to react completely.

3.1.1.2 Moisture Removal. The primary effect of interim stabilization will be the removal of water from the tank. Most of this volume is associated with the saltcakes above the sludges. The effect of dewatering the sludge that contains ferrocyanide must be examined from the standpoint of the reactivity of the remaining mixture. Results of thermal analysis of waste simulant flowsheet sludges indicate that materials containing greater than 15% water by weight will not support a propagating reaction (Fauske 1992).

3.1.1.3 Thermal Response. The drying of the saltcakes is expected to increase their thermal resistivity. This could affect the ability of the tank to cool itself and possibly lead to increased temperatures in the sludge. A decrease in the heat load of the tank through reduction of the heat source with the pumped liquor would be expected to partially offset this effect. However, in the ferrocyanide tanks, the radioactive cesium associated with the sludge layer is expected to remain chemically bound with the ferrocyanide. Therefore, ^{137}Cs removal by pumping is expected to be small (about 5% of the total tank heat load based on supernate sample analysis).

As indicated above, the testing of pure ferrocyanide/oxidant mixtures found the temperature for thermal runaway to be 285 °C (540 °F). However, previous safety assessments on ferrocyanide tank activities assumed a minimum reaction temperature of 200 °C (390 °F). This is the temperature at which early testing of stoichiometric ferrocyanide/nitrate mixtures showed some exothermic behavior. For purposes of this assessment, the lower temperature will continue to be taken as a bounding temperature for safe waste storage.

3.1.2 Nuclear Criticality

Previous safety analysis reports for salt well jet pumping the SSTs have classified the potential for nuclear criticality in a tank as an incredible event. Analytical results from tank core samples consistently show fissile material concentrations at least an order of magnitude lower than the 1 g/L allowed by the criticality prevention specification. Nevertheless, concerns about the effect of removing some of the liquid moderator by pumping have led to the requirement that further pumping to achieve interim stabilization of SSTs will not occur until these effects have been evaluated (Gerton 1992).

3.2 HAZARDS DURING SALT WELL PUMPING FERROCYANIDE WATCHLIST TANKS

A safety study was conducted by WHC to assess the adequacy of existing safety analysis for interim stabilization of tanks by salt well jet pumping (Stahl 1992a). That study included a new hazards assessment (Coles 1992), using a method different from that used in the existing safety analysis reports. The object of the new hazard assessment was to ensure that important hazards associated with the process had been identified.

The study determined that the large majority of hazards had been adequately bounded by existing safety analysis or were judged to be not credible. Five hazards remained, however, that required further detailed accident analysis. They were as follows:

- Breach of waste confinement piping or equipment in SST pump pits, DCRTs, or valve pits, resulting in a liquid spray
- Equipment fires in a SST or DCRT
- Hydrogen accumulation in DCRTs
- Waste stability following mistransfers
- Waste transfer line leaks/breaks.

The risk associated with each was quantified for a particular set of eleven tanks not on a watchlist located in three tank farms: S Farm, T Farm, and U Farm. These risk analyses were examined for this safety assessment for ferrocyanide tanks to determine whether their results bounded the risk from the same hazards in the ferrocyanide tanks under consideration for interim stabilization. The analyses and their applicability to the ferrocyanide tanks are discussed in Section 4.2.

4.0 HAZARD ANALYSIS

4.1 POSTSTABILIZATION STORAGE

Evaluation of the safety of storage in the ferrocyanide tanks after pumping focuses on the changes in the ferrocyanide sludge layer that might be expected as a result of interim stabilization. For reasons discussed in the following sections, it is anticipated that interim stabilization of all the tanks can be completed without changing the ferrocyanide content and moisture content of the sludge layer. In the tanks with significant saltcake overburden, a temperature rise (<30 °F) in the sludge can be expected. However, temperatures are expected to remain below 160 °F, well below the ignition temperature.

4.1.1 Ferrocyanide/Nitrate Concentrations

The best available estimates of the ferrocyanide inventories and ferrocyanide sludge volumes in these tanks come from a model that was based on the records of the ferrocyanide scavenging campaigns (Borsheim 1991). The model provides estimates of the quantities of ferrocyanide and ^{137}Cs and volumes of sludge that were in each tank at the end of the ferrocyanide scavenging campaign. These values were adjusted to account for subsequent transfers of ferrocyanide sludge between tanks. If it is assumed that the saturated saltcake from the concentration process did not mix appreciably with the ferrocyanide layer, diluting it with respect to the ferrocyanide concentration, then the composition of the sludge can conservatively be taken to be the same now as it was then.

The tank liquors to be removed by salt well jet pumping are not expected to remove appreciable amounts of ferrocyanide from the sludge. The majority of liquor that drains into the salt well is from the saltc[illegible].

Liquid samples from three BY tanks show cyanide [illegible] ntrations at 7, 14, and 45 ppm (see Table 1). No specific chem[illegible] for ferrocyanide ion in the samples has been performed. H[illegible] ssuming that the cyanide is all derived from ferrocyanide present in [illegible] mple, the $Fe(CN)_6^{-4}$ concentration in the liquor samples would be between 9 and 60 ppm. For the tank with the greatest amount of pumpable liquor, the maximum amount of ferrocyanide removed would be less than 100 g or about 0.5 mol. Therefore, the analysis of the state of the waste remaining in the tanks after pumping assumes that all the ferrocyanide remains in the sludge layer in the tank.

Table 2 lists the ferrocyanide tanks requiring interim stabilization with an estimation of the bulk ferrocyanide concentration in the sludge layer. The table gives values for sludge with assumed 40 wt% water and for dry sludge. The ferrocyanide content and sludge volumes were based on the historical model discussed above. Other assumptions used for the calculations are that the ferrocyanide is $Na_2NiFe(CN)_6$, the most abundant ferrocyanide species in the tanks, and that the sludge density is 1,500 kg/m^3. The density value is consistent with values determined from sludge samples taken from TY Tank Farms (Grigsby 1992).

Table 2. Bulk Ferr[illegible]e and Oxidant Concentrations in Tanks [illegible]ing Stabilization.

Tank	Ferrocyanide concentration (wt%)		$Na_2NiFe(CN)_6$ + 6 $NaNO_3$ (wt%)	
	40% Water	Dry	40% Water	Dry
BX-106	0.18	0.3	0.47	0.8
BX-110	0.03	0.05	0.08	0.13
BX-111	0.08	0.14	0.21	0.4
BY-103	1.8	2.9	4.6	7.6
BY-105	0.94	1.6	2.5	4.1
BY-106	1.7	2.8	4.4	7.4
T-101	0.05	0.09	0.14	0.2
T-107	0.13	0.22	0.35	0.6

The history of ferrocyanide campaigns and waste transfers indicates that tanks BX-106, BX-110, BX-111, and T-101 probably do not contain appreciable amounts of ferrocyanide and were placed on the watchlist on the basis of inaccurate inventory data. For these tanks, the calculations of sludge contents assumed 1,000 mol of ferrocyanide in the tank, the minimum amount that is the basis for watchlist status.

If the dry ferrocyanide/oxidant estimates are multiplied by a factor of three to allow for uncertainties in the inventory model or for possible uneven distribution of ferrocyanide in the sludge, five of the tanks (BX-106, BX-110, BX-111, T-101, and T-107) still fall below the maximum concentration limit of 9 wt% discussed in Section 3.1.1.1.

4.1.2 Moisture Removal

Sample analyses of tanks containing ferrocyanide in the TY Tank Farm indicate that the minimum water content of the sludge was about 40 wt% (Grigsby 1992). These analyses were made in 1985, about two years after the tanks were interim stabilized by salt well jet pumping. Analysis of waste simulant mixtures made up in the laboratory using the original scavenging recipes confirms that the moisture content of the sludges remains high (>60 wt% for U Plant materials) after compaction by centrifuge to simulate long-term settling (Bechtold 1992).

The volumes of liquor expected to be removed by pumping are calculated based on an assumption that 12.5% of the sludge volume contains free liquid that will drain. An additional assumption is that there is a 2-ft liquid heel at the tank bottom that is held in the sludge by capillary forces. Estimation of expected capillary hold-up height based on average measured surface median particle size diameters of ferrocyanide sludge samples (Grigsby 1992) indicate that for ferrocyanide sludges, the expected capillary height is greater than the 2 ft generally assumed for Hanford Site tank sludges. Hydraulic testing of waste simulants (Wong 1992) indicates particle sizes less than 60 microns for U Plant simulants, with 97% of the mass less than 2 microns in diameter. The material was found to have coefficient of permeability of 5.1×10^{-6} cm/s. These properties are those typically measured in silts and clays. Therefore, the liquid is expected to be undrainable for the sludge heights observed in any of these eight tanks.

In fact, ferrocyanide tanks that have already been salt well jet pumped to meet the low pump flow criterion show interstitial liquid levels substantially greater than the expected 2-ft capillary heel (Klem 1990). Table 3 shows the expected ferrocyanide sludge heights (Borsheim 1991) and the measured interstitial liquid levels in the waste remaining in the ferrocyanide tanks that have been jet pumped.

Table 3. Ferrocyanide Sludge Heights and Interstitial Liquid Levels in Previously Stabilized Tanks.

Tank	Sludge height (in.)	Interstitial liquid level (LOW) (in.)	Liquid height above (below) sludge (in.)
BY-101	<12	59 to 67	47 to 55
BY-104	102	80 to 84	(18 to 22)
BY-107	65	61 to 67	(2) to 4
BY-110	89	71 to 74	(15 to 18)
BY-111	12	48 to 82	36 to 70
BY-112	8	34 to 37	26 to 29
TX-118	<12	53 to 58	41 to 46
TY-103	72	49 to 59	(13 to 23)

All the tanks show interstitial liquid levels greater than 2 ft. In the tanks where the remaining interstitial liquid is all in the sludge layer, the minimum liquid level is about 4 ft. In all cases where the interstitial liquid level is below the sludge level, it is less than 2 ft below it. Therefore, if jet pumping is continued until the low pump flow criterion is reached, it is expected that most, if not all, of the ferrocyanide remaining in the tanks following salt well jet pumping will be saturated with liquor.

Table 4 lists the ferrocyanide tanks that are candidates for interim stabilization with the estimated sludge height for each and an estimate of the amount of sludge that would be less than saturated if a 2-ft and a 4-ft capillary heel is assumed.

Table 4. Anticipated Unsaturated Sludge Volumes Following Stabilization.

Tank	Sludge height (in.)	Volume of sludge not saturated (kgal)	
		2-ft Capillary heel	4-ft Capillary heel
BX-106	<12	0.0	0.0
BX-110	<12	0.0	0.0
BX-111	<12	0.0	0.0
BY-103	84	165	99
BY-105	42	50	0.0
BY-106	90	182	115
T-101	<12	0.0	0.0
T-107	84	165	99

The tanks that would be left with a portion of the sludge layer less than saturated if a 4-ft capillary heel is assumed are BY-103, BY-106, and T-107. It is expected, from the evidence discussed above, that the sludge above the interstitial liquid level will still contain at least 40% moisture. However, if an extra measure of conservatism is desired, the pumping could be halted sometime before the top of the sludge is reached. The interstitial liquid in the sludge would be within the 50,000-gal limit required for interim stabilization.

4.1.3 Ferrocyanide Sludge Temperatures

The temperature histories of ferrocyanide tanks that have been interim stabilized by salt well jet pumping indicate that significant long-term temperature rises have not occurred as a result of jet pumping (Kimura 1990). Table 5 lists the ferrocyanide tanks that have been interim stabilized by salt well jet pumping with maximum annual tank temperatures before and after jet pumping. The shaded areas indicate the year that jet pumping was completed. The values in the table are from manual thermocouple readings taken monthly before 1990 and weekly thereafter.

Table 5. Temperature History of Stabilized Ferrocyanide Tanks.

Tank	Highest yearly temperatures (°F)												
	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92
BY-101		75	96	72	84						76	76	75
BY-104	170	145	164	145	143	158	145	149	136	148	130	129	129
BY-107*											86	94	97
BY-108	117	96	119	118		97					103	102	92
BY-110	139	132	118	147	148	140	145	139	133	136	135	120	122
BY-111						97					87	83	87
BY-112		93				93					84	82	83
TX-118			100	108	85	89					78	78	77
TY-101	80	62	78	68				68	79		71	71	71
TY-103	69	75		64			65				69	69	67

Shaded areas indicate the year the tank was jet pumped.
*Tank BY-107 was jet pumped in 1979.

The two tanks with highest temperatures, tanks BY-104 and BY-110, are also the tanks for which periodic temperature data, recorded over the years before and after jet pumping, are available. Temperature plots over time for these two tanks are shown as Figures 5 and 6 for a thermocouple within the sludge layer (2.3-ft elevation). Both tanks have an overlying saltcake layer. In both cases there is a continual downward trend in temperature consistent with the decrease, from nuclear decay, of the major heat sources in the tank.

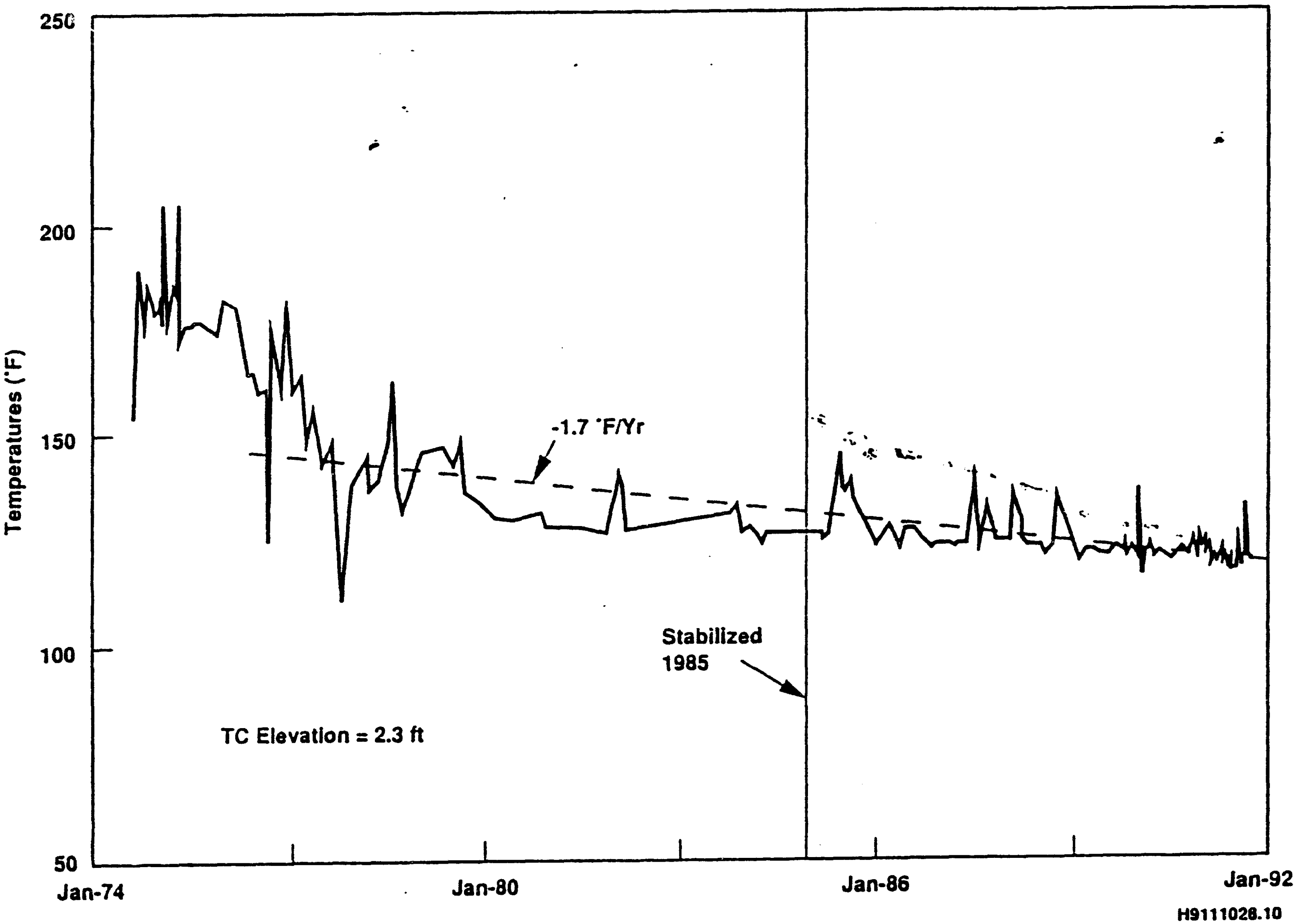

Figure 5. Tank 241-BY-104 Temperature.

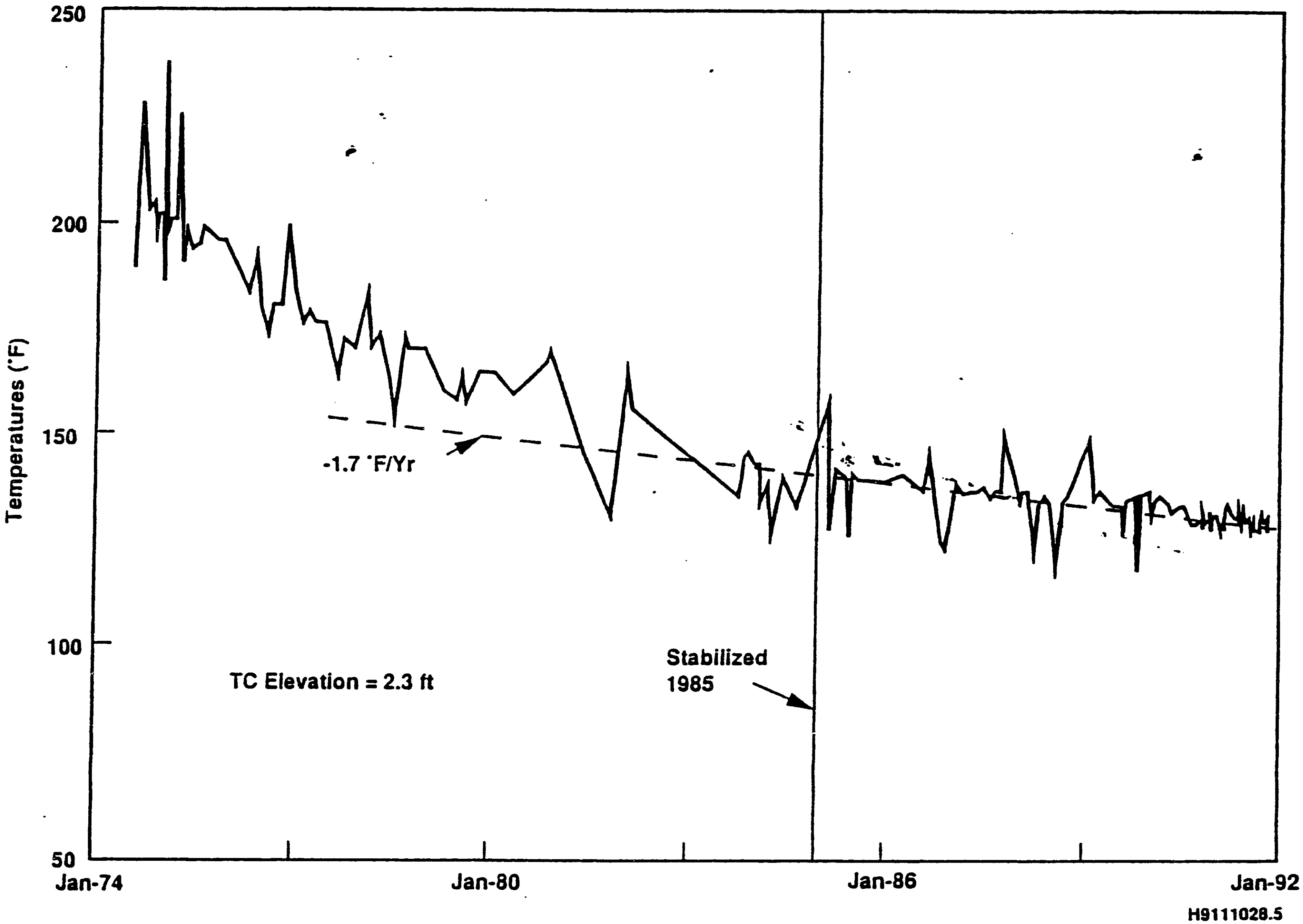

Figure 6. Tank 241-BY-110 Temperature.

Table 6. Summary of Conditions in Tanks After Stabilization.

Tank	Ferrocyanide/nitrate concentration <3 wt%	Sludge fully saturated with liquid	Temperature rise above 200 °C not possible
BX-106	Yes	Yes	Yes
BX-110	Yes	Yes	Yes
BX-111	Yes	Yes	Yes
BY-103	No	No	Yes
BY-105	No	Yes	Yes
BY-106	No	No	Yes
T-101	Yes	Yes	Yes
T-107	Yes	No	Yes

A high degree of conservatism has been built into the criteria. This is to provide a safety envelope large enough to bound the uncertainties in the state of the tanks arising from uncertainties in tank inventories and distribution of components in the sludge layer. The conservative aspects of the criteria are reiterated below.

1. The criterion for ferrocyanide/oxidant concentration is based on a very conservative thermodynamic analysis. Thermal testing of actual tank sludge samples would give a more realistic estimate of actual maximum safe concentrations. If the factor of safety applied to tank inventories were removed, all the tanks would fall below the criterion limit.

2. The requirement for saturation of the sludge ignores the confidence provided by sample data and testing of waste simulant materials that the sludges retain at least 40 wt% moisture without heat input sufficient to release it.

3. The choice of 200 °C as the maximum allowable temperature for the sludge is very conservative because testing on dry waste simulants shows that propagating reactions require much higher initiating temperatures.

4. Each of the three criteria, taken separately, should be enough to ensure against an energetic reaction. The requirement that a tank meet at least two of the criteria provides an extra margin of safety.

It can be seen from the table that tanks BX-106, BX-110, BX-111, BY-105, T-101, and T-107 fall within the established criteria and can be considered safe for pumping. Tanks BY-103 and BY-106 can be brought within the margins if pumping is stopped when the interstitial liquid level reaches the sludge height. This would leave maximum drainable liquid in the tanks of 18,000 and 20,000 gal respectively (assuming the drainable liquid volume fraction of the sludge is 0.125). These volumes are well within the established criterion (less than 50,000 gal drainable interstitial liquid) for declaring a tank interim stabilized.

Therefore, it is recommended that jet pumping on these two tanks be stopped when the interstitial liquid level, as measured at the LOW, is at the calculated sludge height. If evidence from the hydraulic testing of waste simulants and sampling of previously stabilized tank sludges provide greater assurance of the intrinsic ability of the ferrocyanide sludges to retain well above 15 wt% water, this recommendation can be relaxed.

4.2 HAZARD ANALYSIS FOR INTERIM STABILIZATION ACTIVITIES

The *Safety Study of Interim Stabilization of Nonwatchlist Single Shell Tanks* (Stahl 1992a) identified safety issues already adequately evaluated in previous safety documentation for SSTs as well as other new issues that require further action to support an educated decision on the safety of interim stabilization activities. The approach used in conducting the safety study was to evaluate the adequacy of applicable existing safety studies and identify and determine the significance of hazards associated with the pumping process. Detailed accident analysis was performed and conclusions derived regarding the risk from stabilizing a specific set of tanks not on a watchlist. Recommendations for improved controls were formulated with the consideration given to the hazards and existing controls and risk acceptance evaluation results.

The facilities and equipment included in the study were those associated with the SSTs, the salt well jet pump equipment and jumper assemblies, pump pits, valve pits, DCRT, waste transfer line piping and associated instrumentation, alarms, safety interlocks, and control equipment. Processes and controls evaluated included those associated with the interim stabilization process preparation, startup, pumping, and postpumping monitoring. Waste stability issues were also evaluated as they apply to tanks not on a watchlist, facilities, and equipment. The watchlist issues of flammable gas generation, high heat, organics, ferrocyanide, and criticality were evaluated for their potential applicability to the wastes within the designated or inadvertent receiving vessels.

4.2.1 Application of Pumping Study to Ferrocyanide Tanks

The eight ferrocyanide watchlist SSTs (241-BX-106, -110, -111; 241-BY-103, -105, -106; 241-T-101, -107) proposed for interim stabilization are in three tank farms; BX Farm, BY Farm, and T Farm. A waste transfer procedure specific to the tank farm to be pumped will have to be available before initiation of pumping the specified tanks in BX, BY, and T Tank Farms. For the study of tanks not on a watchlist, these procedures were not available and, therefore, the study (Stahl 1992a) assumed that the routes used would be similar to the routes presently defined in the *Single Shell Tank Leak Emergency Response Guide*. (Lo 1991)

Since the emergency response guide describes pumping routes for all SST farms including the BX, BY, and T farms, it is expected that pumping routes for the watchlist and nonwatchlist tanks will be similar and that the facilities and equipment included in the nonwatchlist study are, therefore, representative of pumping watchlist tanks.

Furthermore, the master logic diagram (MLD) for the tanks not on a watchlist (Coles 1992) considered airborne releases from ferrocyanide explosions outside the SSTs. It hypothesized that without comprehensive physical sampling of the tank waste there is some uncertainty about the makeup of the waste and, therefore, it can be assumed explosive substances can exist. However, the possibility of ferrocyanide explosion was discounted since waste material hot spots were not considered credible outside the SSTs and the moisture content inside the DCRT would be too high. (Stahl 1992b)

Since the safety study of the tanks not on a watchlist concludes that a ferrocyanide explosion is incredible ($<10^{-6}$ events/year) outside a SST even when a potentially explosive substance exists in the tank, the same conclusion is applicable to the ferrocyanide tanks. In addition, analyses of supernate samples from the BX and BY tanks (see Table 1) indicate very low potential for significant ferrocyanide content of the pumped liquor. Therefore, the potential for an explosive ferrocyanide mixture outside the tank is eliminated.

4.2.2 Analysis of Special Hazards Identified by Safety Study

The risk assessment and accident consequence analysis for the special hazards identified in the *Safety Study of Interim Stabilization of Nonwatchlist Single Shell Tanks* (Stahl 1992a) were examined for their relevance to the ferrocyanide tanks. A discussion of each follows.

Spray Leak--The event analyzed was a spray leak from a breached jumper connector in a DCRT pump pit. The most significant factor contributing to potential consequences from the leak was determined to be the possibility of the breach occurring while a cover block was not in place. The frequency of this event was evaluated as 0.011 events/year for the 244-TX DCRT. The frequency for 244-BX is expected to be the same because the DCRT configurations are the same.

The maximum dose consequences for a spray leak while the cover block was not in place were found for the U Farm. The consequence was 13.0 rem effective dose equivalent (EDE) to the onsite individual and 5.4×10^{-2} rem EDE from inhalation offsite. The onsite dose was reduced to insignificant if the cover block was assumed to be in place to contain the leak.

The source term for the dose consequence analysis is based on the radionuclide content of the pumped liquor. The values used for the analysis of the U Farm tanks are greater than those determined for the supernate samples from the ferrocyanide tanks. Therefore, the risk analysis for a spray leak event during pumping of one of the eight ferrocyanide tanks is bounded by the analysis performed to evaluate this event for tanks not on a watchlist.

Equipment Fire--Event tree analysis demonstrated that end-state conditions resulting from equipment fires were bounded by existing safety analysis. Examination of other fire related events in SSTs and DCRTs led to the conclusion that none were credible. It is concluded that existing safety analysis bounds the risk and consequences for equipment fires in the ferrocyanide tanks.

Hydrogen Accumulation in DCRTs--The evaluated frequency of a fire or explosion because of hydrogen accumulation in a DCRT was the same, 0.34 events/year, for all DCRTs considered. Therefore, it is not expected to be different for the tanks considered in this safety assessment.

The dose consequences from a hydrogen explosion in the 244-TX DCRT were 0.23 rem EDE onsite and 3.3 x 10^{-4} rem EDE offsite. Since the configuration of the 244-BX DCRT is the same as the 244-TX DCRT, the analysis is valid for the ferrocyanide tanks covered in this study, with only the source term differing.

The source term is determined by the hydrogen generation rate and the concentration of radionuclides in the material released from the tank. Both of these factors are a function of the radionuclide content of the liquid contents of the tank. Therefore, the consequences of a hydrogen explosion in the DCRT for the eight ferrocyanide tanks are expected to be lower than those calculated for the tanks not on a watchlist because the radionuclide content of the pumped liquor is lower for the ferrocyanide tanks.

Waste Stability--The safety study for stabilization of tanks not on a watchlist concluded that there is no increase in risk or any dose consequences expected as a result of inadvertent addition to a tank because of mistransfer or drainback during pumping. The same is expected to be true for the ferrocyanide tanks because no appreciable ferrocyanide is present in the liquor.

Waste Transfer Line Leaks/Breaks--The frequency and consequences of leaks to the ground from transfer line breaks during pumping were calculated for the tanks not on a watchlist. The frequencies for the maximum release from pumping the BX and BY tanks are expected to be similar to those in the T and U farms. The consequences are bounded by those analyzed because of the lower source term.

Consequently, stabilization of the ferrocyanide watchlist tanks by jet pumping is judged to be adequately bounded by the existing safety analysis and the safety study for stabilizing tanks not on a watchlist.

5.0 CONSEQUENCES OF ACCIDENTS

No new accident consequences were calculated as a result of this safety assessment. Consequences of likely accident scenarios during the jet pumping process have been calculated as part of other safety analyses (Hanson 1980, Hanson 1981, and Stahl 1992a).

It is judged to be extremely unlikely that all the conditions required for propagating an energetic ferrocyanide reaction exist simultaneously in any of the ferrocyanide tanks addressed in this safety assessment. Salt well jet pumping is not expected to increase the likelihood of the event because changes in the composition of the ferrocyanide sludge are not expected.

6.0 CONTROLS

Procedures and operational safety requirements for interim stabilization of SSTs are in place. Salt well jet pumping of the tanks will not be performed until the administrative hold imposed by the JCO for the nuclear criticality USQ is lifted.

The *Safety Study for Interim Stabilization of Nonwatchlist Tanks* (Stahl 1992a) identified two accident scenarios, spray leaks and DCRT hydrogen accumulation, for which the potential dose consequences to onsite personnel exceed risk comparison guidelines. That document recommended controls that would reduce the consequences to acceptable levels. Those controls shall be required for interim stabilization activities in the ferrocyanide tanks. They are as follows.

- Ensure that all cover blocks are in place on all facilities (including SST pump pits, valve pits, and DCRTs) before initiating pumping and that no cover blocks are removed until pumping through the affected facility is shut down. Ensure that cover blocks are properly reinstalled after maintenance activities before pumping is resumed.
- Ensure that DCRT ventilation systems are operational and continually operated at a flow rate great enough to ensure complete mixing in the freeboard space during all waste transfers and retentions in the affected DCRT.

A control is required to preserve the conservatism of the analysis of the potential hazard posed by the reactivity of the tank contents.

- For tanks BY-103 and BY-106 monitor liquid level at the LOW and discontinue pumping when the interstitial liquid level reaches the sludge level. If future testing of waste simulants and tank samples provides more confidence in the capability of the ferrocyanide sludge to retain significant moisture, or that the sludge in these tanks is nonreactive, this requirement may be relaxed.

Additional controls imposed by previous safety assessments for ferrocyanide tank activities shall be followed (Farley 1992). These controls apply whenever tank confinement is opened to the atmosphere (e.g., opening a riser or uncovering the pump pit for pump installation or maintenance). The controls address potential hazards to workers presented by flammable or toxic gases that might be present in the tank atmosphere.

- Before salt well pump installation in a ferrocyanide tank, the tank vapor space gases shall have been sampled and analyzed to determine toxic and flammable constituents. Standard tank farm methodology shall be used as defined by the Industrial Hygiene and Safety organization. The sampling procedure must have occurred within a year prior to pump installation.

- Contamination control shall be provided around the pump pit or opened riser. The means of contamination control shall be specified by a Health Physics Technician.

- Personnel breaking confinement shall be on supplied fresh air. Personnel within 28 ft of an open riser or other release point shall be supplied fresh air. Respiratory protection for other personnel in the tank farm will be as specified by the Industrial Hygiene and Safety organization.

- Before opening the pump pit or any riser, combustible gas shall be measured at the HEPA exhaust. After the bolts holding the riser flange are loosened enough to take a gas sample from the riser, but before complete removal of the riser cover, another gas sample shall be taken at the top of the riser. After flange cover removal, a sample shall be taken in the tank vapor space below the riser. This shall be done with an Industrial Scientific Model MX241 or MX251 (or equivalent) flammability meter calibrated on a methane standard. If the combustible gas level is greater than 20% of the lower flammability limit (LFL) at any of the three locations, pump installation activities shall not proceed.

- After riser cover or pump pit cover removal, readings for toxic gas shall be made at the opening by a field representative from the Industrial Hygiene and Safety organization. Readings for toxic gas in the worker breathing zone shall also be made every 15 minutes, whenever the pump pit or a riser is open. Because of the nature of the waste in the tank, gas monitoring shall include testing for hydrogen cyanide and hydrazine in addition to the gases normally monitored (e.g., ammonia, nitrous oxide, nitrogen dioxide, organic vapors, hydrogen)

- The equipment installation and operation procedures (along with this safety assessment) shall be reviewed by Radiation Protection personnel to determine specific radiation protection requirements. A job hazard review shall also be performed by Industrial Safety.

The controls and operating conditions discussed in this section must be addressed in the procedures, work package, training and other appropriate documentation, and observed in conducting the work. Preparation for interim stabilization of ferrocyanide tanks shall include a review of this safety assessment and other applicable safety documentation to ensure the continued validity of the analysis in light of increased understanding of the tanks' contents and of changes in the equipment or process.

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Section 4.2

Environmental Assessment for Pumping 241-T-101

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ENVIRONMENTAL ASSESSMENT FOR INTERIM STABILIZATION OF EIGHT HANFORD SINGLE-SHELL TANKS CONTAINING FERROCYANIDE

Hanford Site
Richland, Washington

ENVIRONMENTAL ASSESSMENT

DOE/EA

October 1992

DOCUMENT CONTENTS

ENVIRONMENTAL ASSESSMENT FOR INTERIM STABILIZATION OF EIGHT HANFORD SINGLE-SHELL TANKS CONTAINING FERROCYANIDE

EXECUTIVE SUMMARY

The proposed action involves interim stabilization[1] of eight Hanford single-shell tanks (SST) that are on record as containing greater than 1,000 gram-moles of ferrocyanide. These eight tanks containing ferrocyanide that require interim stabilization are 241-BX-106, 241-BX-110, 241-BX-111, 241-BY-103, 241-BY-105, 241-BY-106, 241-T-101, and 241-T-107.

The U.S. Department of Energy (DOE) proposes to take this action to reduce the amount of radioactive liquids available for release to the environment from potential tank leaks. Interim stabilization would be performed using existing saltwell pumping systems that are in place subsequent to being recertified for use.

Standard operating procedures for interim stabilization have been prepared and reviewed to reflect the potential presence of flammable or explosive ferrocyanide-nitrate/nitrite waste mixtures in the waste and other hazardous conditions.

1.0 INTRODUCTION

DOE is responsible for the management and storage of high-level waste accumulated as a result of the processing of defense reactor irradiated fuels for plutonium recovery at the Hanford Site. These wastes include liquids and precipitated solids stored in underground single-shell storage tanks which are pending final disposition. The goal of this proposed action to interim stabilize eight tanks containing ferrocyanide-nitrate/nitrite waste mixtures that have not been interim stabilized, to reduce the environmental, safety, and health risks inherent in these Hanford tanks. The highest priority for this program is to identify a corrective action strategy for each priority waste tank safety issue and to mitigate known safety concerns.

The 1987 Environmental Impact Statement (DOE 1987) "Disposal of Hanford High-Level Transuranic and Tank Wastes," (DOE/EIS-0113) projected that the maximum foreseeable accident associated with high-level waste management operations would be an explosion of a ferrocyanide containing high-level waste tank. The 1987 EIS projected that such an explosion would result in a short-term radiation dose to the maximally exposed member of the public to 200

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[1]. By definition, a storage tank is <u>interim stabilized</u> it if contains less than 5,000 gallons (approximately 13,000 liters) of supernate and less than 50,000 gallons (approximately 130,000 liters) of drainable interstitial liquid associated with the waste solids. If the tank was jet pumped to achieve interim stabilization, then the jet pump flow must also have been at or below 0.05 gallons per minute before interim stabilization criteria is met.

millirem, and an offsite collective 70-year population dose commitment of 7,000 person-rem. Such an explosion would be expected to result in four offsite latent cancer fatalities, the contamination of a substantial area of land, and a significant dose to the workers. However, a 1990 General Accounting Office (GAO) study (Peach 1990) estimated that the consequences of this event could be 10 to 100 time greater than those projected in the 1987 EIS. Although the GAO study did not reach a conclusion regarding the probability of a tank explosion, an independent DOE review panel (Kress 1990) determined that the probability of such an explosion is low.

Commitments under the Hanford Federal Facility Agreement and Conset Order (Tri-Party Agreement) (Ecology 1989) require that all 149 single-shell tanks be interim stabilized by September 1996. To date, 105 of the 149 single-shell tanks have been interim stabilized. The process is nearly completed for an additional five tanks. Of the 24 tanks on the ferrocyanide watchlist, 17 were either interim stabilized by saltwell jet pumping before the Unreviewed Safety Question was declared or were judged to contain too little free liquid to require pumping (administratively stabilized). To meet the Tri-Party Agreement commitment, the safety of interim stabilizing the remaining eight tanks containing ferrocyanide must be established.

Aside from the committed Tri-Pary Agreement schedule, DOE must be prepared to commence pumping a tank as soon as safely possible after it has been identified as an assumed leaker. The Single-Shell Tank Leak Emergency Response Guide (Lo 1991) outlines actions to be taken. The ferrocyanide tanks have been declared an Unreviewed Safety Question because their consequences potentially exceed previously reported safety analysis and 1987 EIS consequences.

This environmental assessment (EA) has been prepared to provide a basis for determining whether the proposed action may have a significant impact on the quality of the environment and to support the decision for either preparing an EIS or issuing a "Finding of No Significant Impact" (FONSI). This EA implements the requirements of the National Environmental Policy Act (NEPA) of 1969, the implementing regulations issued by the Council on Environmental Quality (40 CFR Parts 1500-1508), and DOE's NEPA regulations (10 CFR Part 1021; 57 Federal Register 15122, April 24, 1992).

2.0 PURPOSE AND NEED FOR ACTION

The purpose for this action is to interim stabilize and isolate eight Hanford single-shell tanks that are on record as containing greater than 1,000 gram-moles of ferrocyanide. This would reduce the amount of radioactive liquids available for release to the environment from potential single-shell tank leaks. Isolation of the tanks involves closing off all pathways by which additional wastes could be introduced to the tanks.

The need for this action is to reduce the amount of radioactive liquids available for release to the environment from future assumed tank leaks. As a result, interim stabilization of the eight single-shell tanks containing ferrocyanide that have not been interim stabilized, would place the tanks in a safe condition with minimal risk of a liquid leak to the environment.

3.0 DESCRIPTION OF THE PROPOSED ACTION

The description of this action is to remove the supernate and drainable interstitial liquid from solid wastes in eight Hanford single-shell tanks containing ferrocyanide. This would be accomplished by saltwell pumping using jet pumps. The saltwell jet pump system includes an 8 or 10 inch (approximately 20 to 25 centimeter) diameter saltwell casing constructed of a saltwell screen welded to schedule 40 carbon steel pipe. The casing and screen are inserted into a 12 inch (approx. 30 centimeter) tank riser located within the pump pit and suspended nearly to the bottom of the tank within the tank waste. The saltwell screen consists of a length of 300 series 8 to 10 inch (20 to 25 centimeter) diameter stainless steel pipe with screen openings of 0.05 inch (0.127 centimeter) provided for interstitial liquid to flow through. A jet assembly, with a foot valve, is mounted to the base of two pipes which are located inside of the saltwell screen and ixtends from the top of the cell to near the bottom of the well casing. Also inside the saltwell screen are specific gravity and weight factor dip tubes.

The liquid waste from these tanks would be pumped to a double contained receiver tanks (DCRT) at low pumping rates [0.05 to about 5.0 gallons per minute (approximately 0.2 to 19 liters per minute)]. The liquid accumulated in the DCRT eventually would be transferred to double-shell tanks (DST), or is sent into the waste concentration system for volume reduction (Figure xx). Pumping f· ɔm the DCRT to other facilities would be the action of other NEPA document ion.

The facilities and process equipment generally needed for the interim stabilization by saltwell jet pumping of the single-shell tanks are:

1. Single-shell waste storage tank
2. Pump pit, saltwell screen, jet pump assembly, and jet pump jumper assembly
3. Transfer piping and valve pits
4. DCRT
5. Associated instrumentation, alarms, and controls
6. Double-shell waste storage tank.

Prior to starting the proposed activities, gas sampling of the tank's vapor space would be completed to determine that no flammable gases greater than 25 percent of the respective LFLs are present using a calibrated gas flammability meter as described in WHC 1991a.

The temperature histories of ferrocyanide tanks that have been interim stabilized by salt well jet pumping indicate that significant long-term temperature rises have not occurred as a result of jet pumping (Kimura, 1990). Table TBD lists the ferrocyanide tanks that have been interim stabilized by saltwell jet pumping with maximum annual tank temperatures before and after jet pumping. The shaded areas indicate the year that jet pumping was completed.

TABLE 1: HIGHEST YEARLY FECN TANK TEMPERATURES

Tank	Highest Yearly Temperatures (°F)												
	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92
101-BY		75	96	72	84						76	76	75
104-BY	170	145	164	145	143	158	145	149	136	148	130	129	129
107-BY*											86	94	97
108-BY	117	96	119	118		97					103	102	92
110-BY	139	132	118	147	148	140	145	139	133	136	135	120	122
111-BY						97					87	83	87
112-BY		93				93					84	82	83
118-TX			100	108	85	89					78	78	77
101-TY	80	62	78	68				68	79		71	71	71
103-TY	69	75		64			65				69	69	67

* Tank 107-BY was jet pumped in 1979.

The two tanks with highest temperatures, tanks 104-BY and 110-BY, are also the tanks for which continual temperature data are available.

The maximum expected temperature rise in any tank due to dryout of the saltcake can be estimated from the current steady state temperature change across the wet saltcake and the expected change in saltcake thermal conductivity. Of the seven tanks examined in this study, tank 106-BY has the highest temperature as well as the greatest temperature difference across the saltcake layer. Therefore, it is taken as the worst case tank from the standpoint of anticipated maximum temperature rise after pumping.

If the thermal conductivity of the saltcake layer is decreased by 1/2 because of moisture removal, then the expected temperature difference across the saltcake would be expected to double, all other parameters remaining equal. In fact, the thermal conductivity of dry saltcake has been conservatively estimated to be about 60% that of wet saltcake (McLaren, 1991).

December, 1991 temperature measurements from tank 106-BY indicate that the temperature difference across the saltcake layer 16.6 feet (approximately 5.1 meters) is about 40°F (approximately 4°C), and the maximum tank temperature is 130°F (approximately 54°C). The expected temperature difference, with the lower thermal conductivity, would be about 70°F (approximately 21 °C). This translates to a maximum sludge temperature of 130 °F (approximately 54°C) plus

30°F (approximately -1°C), or 160 °F (approximately 70°C). This is less than half the minimum temperature of concern for a ferrocyanide propagating reaction even given optimum ferrocyanide, oxidant and moisture content.

Neither the history of temperature response from interim stabilized ferrocyanide tanks with saltcake layers, nor the physical response of the tank expected from drying the saltcake, supports the proposition that pumping would cause temperatures of concern in the ferrocyanide sludge. Therefore, it is concluded that the likelihood of acheiving high enough temperatures to initiate an energetic ferrocyanide reaction is extremely low.

3.1 Single-Shell Waste Storage Tanks: The underground SSTs considered in this environmental assessment are two sizes. Tanks in the 241-BX and 241-T Tank Farms have a nominal capacity of 530,000 gallons (approximately 2,000,000 liters), while the capacity of the tanks in the 241-BY Tank Farm is 750,000 gallons (approximately 2,840,000 liters). The tanks are constructed of reinforced concrete with a mild steel liner covering the bottom and sidewalls.

All of the SSTs have been inactive since 1980 and no waste transfers into the tanks have been made since that time, and none are planned for the future. All the subject tanks are passively ventilated through a riser with High Efficiency Particulate Air (HEPA) filtration.

The temperature and waste level data in the subject tanks are taken regularly and recorded.

3.2 Saltwell and Jet Pump: The equipment and installations required at the single-shell tanks for jet pumping from the saltwell are: 1.) a pump pit; 2.) a saltwell screen; 3.) a jet pump assembly consisting of a centrifugal pump and jet assembly; 4.) jet pump jumpers; and 5.) associated instrumentation and control.

Important instrument and control systems at the tank associated with saltwell pumping include: 1.) leak detection; 2.) jet pump system controls including limit switches and safety interlocks; and 3.) weight factor and specific gravity measurement.

Leak detection is provided in each pump pit in the saltwell system. Leak detection is a single pit is interlocked to shut down the pump in that pit as well as all pumps on the same manifold.

3.3 Transfer Piping and Valve Pit: Transfer lines designated for transfer of waste from the 241-BX, 241-BY, and 241-T tanks to the DCRT are direct buried lines with three feet of ground cover to provide shielding. These lines are carbon steel welded pipe. All transfer lines are sloped for drainage.

The design life of all saltwell pumping transfer lines is five years. They are now more than 10 years old. Therefore, the lines must be pressure tested prior to use and within the six month period previous to their use to assure against leaks.

Flow from the tanks to the receiver tank is routed through a valve pit. In the valve pit, the flow from the sending tanks' transfer lines routed through a manifold to the receiving tank line by a series of valves and jumper connections. Two and three way valves are built into each jumper to divert the flow where needed. Valve pits are concrete boxed with heavy cover blocks. Leak detection in the valve pit is interlocked with corresponding pumps. A drain line in the valve pit connects to a flush pit.

3.4 Double Contained Receiver Tanks: Saltwell waste from the 241-BX and 241-BY Tank Farms will be accumulated in DCRT 244-BX. The saltwell waste from the 241-T Tank Farm will go to the 244-TX DCRT.

The 244-BX and 244-TX DCRTs are 25,000 gallon (approximately 94,600 liters) cylindrical tanks. The tank is positioned with its axis horizontal in the lower section of a reinforced concrete vault. Above the tank vault, and connected to it are a pump pit and a filter pit. An instrument enclosure is also above the tank vault, but not connected to it.

The ventilation system maintains the receiver vessel and annulus under negative pressure with respect to atmosphere to prevent the release of radioactive material in case of a tank breach. Supply air is taken into the tank annulus through a roughing filter and a HEPA filter. The exhaust system pulls air from the annulus and the inner tank through a roughing filter and two stages of HEPA filter.

For safety operation, the ventilation system has dampers and valves for regulation and isolation, measurement of differential pressure across the filters, continuous radioactive particulate monitoring and record sampling of exhaust air, and continuous flow measurement of exhaust air.

4.0 ALTERNATIVE TO THE PROPOSED ACTION

4.1 No Action Alternative

Alternatives to interim stabilization by saltwell jet pumping have been proposed. The "no action" alternative, to permit the SST's to leak their contents to the ground, is unacceptable in light of commitments to prevent further contamination of Hanford soils.

This alternative does not satisfy the specific need for DOE action identified in Section 2.0. DOE has determined that the risk of the No Action Alternative would be greater than the risk of the proposed actions.

4.2 Other Alternatives

Other alternatives to saltwell jet pumping are: 1) engineered barriers around the tanks to fix or confine the leaking wastes in a limited volume of soil, and 2) in-tank solidification of the wastes by processes such as glassification. The extent of technology development necessary to realize either of these options prevents their usefulness for the near term minimization of releases to the environment. They have not been ruled out as long term options, however. There are no other reasonable alternatives immediately available to the proposed action.

All of the activities of the proposed action are required to meet the needs identified in Section 2.0.

5.0 AFFECTED ENVIRONMENT

The Hanford Site is 560 square miles (1,450 square kilometers) of essentially flat to gently rolling treeless desert, although some trees are found along the Columbia River. There are two mountains: Rattlesnake Mountain, which is a treeless anticline, at an elevation of 3,500 feet (1,066 meters) above sea level, on the southwestern edge of the site, and Gable Mountain, a small ridge 1,112 feet (339 meters) high, north of the 200 East Area.

The 241-BX and 241-BY Tank Farms are located in the 200 East Area of the Hanford Site approximately 10 miles (approximately 16 kilometers) west of the Columbia River, the nearest natural watercourse. The nearest population center in the City of Richland, Washington, about 20 miles (about 32 kilometers) south. The 241-T Tank Farm is located in the 200 West Area of the Hanford Site about five miles (eight kilometers) south of the Columbia River and about 25 miles (about 40 kilometers) northwest of the City of Richland, Washington.

The Hanford Site has a mild climate with six to seven inches (15 to 18 centimeters) of annual precipitation and occasional high winds up to 80 miles (129 kilometers) per hour. The annual probability of a tornado hitting any given location on the site is estimated at ten chances in one million. The Hanford Site has low to moderate seismicity.

The proposed action would not take place on a floodplain or wetland. It would take place at an existing facility in a previously disturbed area. No species of plant or animal, that is federally registered as rare, threatened, or endangered, is known to depend on the habitats unique to the Hanford Site. No impacts to critical habitat or environmentally sensitive areas such as archaeological, historical, or native American religious sites are anticipated (PNL 1991).

6.0 ENVIRONMENTAL IMPACTS

6.1 Routine Operations

The proposed action would not be expected to result in any radiological or hazardous material releases to the environment. Appropriate procedures and administrative controls would be in place prior to the proposed work to maintain radiation exposure to onsite personnel below DOE orders and contractor guidelines (five and one rem per year, respectively) and in keeping with the philosophy of As Low As Reasonably Achievable. Radiation and hazardous chemical levels at the site and exposure to the workers would be continuously monitored during the proposed action.

The radiological dose to a member of the public from this action would be extremely small relative to the annual dose limits set in DOE Order 5480.4 (DOE 1991a) and 40 CFR 61 and would not be expected to result in any health effects.

Small quantities of hazardous materials (e.g., solvents, cleaning agents, etc.) which may be generated during the proposed action would be managed and disposed of in accordance with applicable federal and state regulations. Any radioactive material, radioactively-contaminated equipment or radioactive mixed wastes that might be generated by the proposed action would be appropriately packaged and stored/disposed of at existing waste management facilities on the Hanford Site. Asbestos gaskets may be encountered on riser covers to be removed. The contractor would remove, package, and dispose of the asbestos in accordance with all applicable contractor controls and federal and state regulations. None of these wastes are expected to contribute significantly to the volume of waste generated annually at the Hanford Site [e.g., the recorded total volume of waste received at the 200 Areas for storage or disposal in calendar year 1990 was 213,000 cubic feet (approximately 6,000 cubic meters)].

During routine operations, a lightning strike caused-ignition of the waste in the tank has a calculated probability of occurrence to be 6.4 in ten million [$6.4(10^{-6})$] (WHC 1992). Considering the low probability of occurrence of this event the risks associated with this accident scenario are low. Administrative controls are in place that would minimize the risk by precluding the proposed action from taking place during adverse regional meteorological conditions.

Previous safety analysis reports for saltwell jet pumping the single-shell tanks have classified the potential for nuclear criticality in a tank as an incredible event (probability of occurrence of less than one in a million). Analytical results from tank core samples consistently show fissile material concentrations at least an order of magnitude lower than the one gram per liter allowed by the criticality prevention specification. Nevertheless, concerns about the effect of removing some of the liquid moderator by pumping have led to the requirement that further pumping to achieve interim stabilization os single-shell tanks will not occur until these effects have been evaluated further. This work is in progress (Gerton 1992).

6.2 Accident Risks

The proposed action has been reviewed in safety evaluations (Hanson 1980, Hanson 1981). The evaluation of the accidents scenarios is in the following sections, and the potential accidents have been identified. The major concerns are related to the potential for personnel exposure to vented gases and the potential for spark generation. Procedures for mitigation of both of these concerns are in place.

The potential accident scenarios are as follows:

- Spray Leak from a Breached Jumper Connector in a DCRT Pump Pit
- Equipment Fires in a SST or DCRT
- Hydrogen Accumulation in DCRTs
- Waste Stability Following Mistransfers
- Waste Transfer Line Leaks/Breaks

6.2.1 Spray Leak from a Breached Jumper Connector in a DCRT Pump Pit: The scenario for a spray leak from a breached jumper connector in a DCRT pump pit is a worker safety concern. As discussed in the safety assessment, the most significant factor contributing to potential consequences from a leak was determined to be the possibility of a breach of containment occurring while a cover block was not in place. The frequency of this event was evaluated in the safety assessment as 0.011 events/year for the 244-TX DCRT. The frequency for the 244-BX DCRT is expected to be the same because the DCRT configurations are the same.

The source term for the dose consequence is based on the radionuclide content of the pumped liquor. The values used for the analysis of the non-watchlist tanks in the U Tank Farm are greater than those determined for the supernate samples from the ferrocyanide tanks. The safety analysis bounds this proposed action. The dose consequence was 13.0 rem effective dose equivalent (EDE) to the onsite individual and $5.4(10^{-2})$ rem EDE from inhalation to the offsite individual. The onsite dose consequence was reduced to insignificant if the cover blocks were assumed to be in place to contain the leak. Therefore, the risk analysis for a spray leak event during pumping of one of the eight ferrocyanide tanks is bounded by the analysis performed to evaluate this event for non-watchlist tanks (Kummerer 1992, Stahl 1992).

6.2.2 Equipment Fires in a SST or DCRT: Event tree analysis in the safety assessment demonstrated that end-state conditions resulting from equipment fires were bounded by existing safety analysis. Examination of other fire related events in SSTs and DCRTs led to the conclusion that none were credible. It was concluded that existing safety analysis bounds the risk and consequences for equipment fires in the ferrocyanide tanks (Kummerer 1992, Stahl 1992).

6.2.3 Hydrogen Accumulation in DCRTs: The frequency of a fire or explosion because of hydrogen accumulation in a DCRT was evaluated to be the same, 0.34 events per year, for all DCRTs considered. Therefore, it is not expected to be different for the ferrocyanide tanks considered in this environmental assessment.

The hydrogen generation rate and the concentration of radionuclides in the material released from the tank determines the source term. These factors are a function of the radionuclide content of the tank. As a result, the consequences of a hydrogen explosion is the DCRT for the eight ferrocyanide tanks are expected to be lower than those calculated for the tanks not on a watchlist because the radionuclide content of the pumped liquor is lower for the tanks containing ferrocyanide (Kummerer 1991). As a result, the health consequences are expected to be lower than for the non-watchlist tanks.

6.2.4 Waste Stability Following Mistransfers: The safety study for non-watchlist tank stabilization concluded that there is no increase in risk or any dose consequences expected as a result of inadvertent addition to a tank because of mistransfer or drain back during pumping. The same is expected to be true for the ferrocyanide tanks since no large concentration of ferrocyanide is present in the liquor. Therefore, no expected frequency calculations were performed in the safety assessment (Kummerer 1991, Stahl 1992) and as a result, no health effects are expected.

6.2.5 Waste Transfer Line Leaks/Breaks: The frequency and consequences of leaks to the ground from transfer line breaks during pumping were calculated for the non-watchlist tanks in the S, T, and U Tank Farms. The frequency for the S Tank Farm was 7.9 events per year for a small leak given the longer length and age of the piping expected to be utilized. The dose consequences from this event were calculated as $7.6(10^{-3})$ rem EDE onsite and $2.3(10^{-5})$ rem EDE offsite for postulated leaks with surface pooling of 48 gallons of waste liquid. The frequencies for the maximum release from pumping the BX and BY tanks are expected to be similar to those in the non-watchlist tanks in T and U Tank Farms. The consequences for the ferrocyanide tanks are bounded by those analyzed because of the lower source term.

6.3 Cumulative Impacts

The radiological impact of waste tank storage operations on the population is well within applicable standards and is far below normal background radiation levels (DOE 1990). The proposed action would not change the onsite or offsite dose from routine operations (DOE 1991c). The effect of the proposed action would be to reduce the risk of a leak to the environment from a single-shell tank containing ferrocyanide that has not been interim stabilized.

The safety assessment determined the it would be extremely unlikely that all the conditions required for propagating an energetic ferrocyanide reaction could exist simultaneously in any of the ferrocyanide tanks addressed in this action. Saltwell jet pumping in not expected to increase the likelihood of the event because changes in the composition of the ferrocyanide sludge are not expected. Consequently, stabilization of the ferrocyanide watchlist tanks by jet pumping is judged to be adequately bounded by existing safety analyses and the safety study for stabilizing non-watchlist tanks (Kummerer 1992, Stahl 1992).

As a result, the dose consequences and latent cancer fatalities for interim stabilization of the ferrocyanide watchlist tanks by jet pumping would be judged to be adequately bounded by the existing safety analysis and the safety study for stabilizing tanks not on a watchlist (Kummerer 1992, Stahl 1992).

With respect to cumulative effects, the proposed action would not increase the routine impacts associated with the continued operations of Hanford Site tank farms (DOE 1980).

7.0 PERMITS AND REGULATORY REQUIREMENTS

The SST system is being operated under interim status as a treatment and storage unit under WAC 173-303. A dangerous waste closure/post-closure plan would be submitted to the State of Washington Department of Ecology (Ecology) for closure of the SST Farms (Hanford Federal Facility Agreement and Consent Order Milestone M-9-02).

Notification and approval from the State of Washington Department of Health would be required if there is a potential increase in air emissions of any radioactive material. In this case, potential is defined as more likely than not to occur during normal operations or reasonably expected upsets.

There are no permits specifically required for this proposed action.

Notification of the State of Washington Department of Health would be made before the proposed action would be carried out.

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Section 4.3

Safety Analysis of Tank 241-T-101 Transfer to 241-SY-102

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FAILURE STUDY OF

TRANSFER FROM TANK 101-T TO TANK 102-SY

John E. Kelly

November 1992

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101-T TANK WASTE STABILIZATION

1.0 PURPOSE OF STUDY

This study analyzes failures that could lead to some consequences associated with pumping tank 101-T to remove the liquid. Tank 101-T is considered a ferrocyanide tank. Previous analysis have been done on this category of tanks containing ferrocyanide. Also, a study has been completed on the stabilization of nonwatch list single shell tanks. Although tank 101-T is a watch list tank it fits into this category. Of particular interest is any excess heat that is added to the tank since a submersible pump may be used rather than the jet pump considered in the stabilization study. The jet pump driver is outside of the tank and cannot be a heat source. This is not true of the submersible pump. Also of interest to this study is the consequence of a leak associated with the two types of pumps. Another safety issue is an uncontrolled leak in the transfer line from the 101-T tank to the 102-SY tank. This is identical for both pumps and will be evaluated by means of a fault tree model. Discussions will be used to evaluate the addition of heat to the tank due to the pumps being used. Also, the potential for fire will be considered in a discussion.

2.0 SYSTEM FUNCTION

The system function in this case is to provide a means of removing the liquid contents of single shell tank 101-T and transferring it to tank 102-SY. This will include the pump, the pump pit, valve pits, double-shell receiving tanks, and associated valving and instrumentation.

2.1 SAFETY FUNCTION

The 101-T tank stabilization safety function includes pumping the liquid out of the tank and transferring it to the 102-SY tank. The system must contain the waste to prevent contamination spread to the environment, and shutdown the transfer process in case of a leak to prevent the waste from reaching the air, ground, or operations personnel. There are leak detectors in the various pits and in the encasement of the double shell transfer pipes.

3.0 SUCCESS CRITERIA

The success criteria for the 101-T tank stabilization is divided into three parts.

1. Excess heat must not be added to the 101-T tank for fear that it may affect the stability of the ferrocyanide in the tank.

2. Sparks will not be available to any hydrogen collection that could initiate a fire or explosion.

3. The transfer line from the 101-T tank to the 244-TX pump pit (SN-6012) must not have more severe risk than the equivalent line in the stabilization study no matter which pump is chosen (submersible or jet pump).

4. The transfer system must contain the waste in the piping during a transfer, and in the case of a leak, the leak detection system will alarm, and the transfer will be shutdown automatically or manually. The piping or pits and covers will contain the spill to prevent a release to the environment.

4.0 SYSTEM DESCRIPTION

At Hanford, there are 177 underground waste storage tanks. The majority are single-shell tanks (SST). These tanks have been subdivided into the watch-list and nonwatch-list tanks. Some of the nonwatch-list SSTs have been stabilized and some not. Stabilization refers to pumping the liquid waste out of the tank to prevent waste leaks to the environment or ground. In this case, there is a desire to pump tank 101-T dry and transfer the liquid to tank 102-SY. Studies made by Westinghouse have not determined whether waste tank 101-T has leaked, but in the event that it has there is a desire to pump it dry enough to prevent leaks to the ground. 101-T is a single-shell tank with a capacity of 530-thousand gallons. It presently contains 133-thousand gallons of waste. Only 35-thousand gallons is drainable liquid. The remainder is sludge. Tank 101-T was constructed in 1943-44. It was put into service in December 1944. It was taken out of service in 1979. The tank is 75-feet in diameter and 16-feet in height. It is a ferrocyanide watch-list tank. T-Farm consists of 12 single-shell tanks of approximately 500-thousand gallons capacity and four of 55-thousand gallons capacity. It is located in the 200-West Area of Hanford, on the north side of the intersection of Camden Avenue and 23rd Street.

There are two possible solutions to removing the liquids from the tank. One is to use a submersible pump. The planned pump is a 5 hp pump that has been tested to pump water at the rate of 31 gpm. Assuming that 35,000 gallons must be pumped, this would require approximately 18.8 hours of continuous pumping. For the purposes of this investigation, two days will be assumed. The concerns with respect to the submersible pump as compared to the jet pump are electrical sparks in the tank, additional heat added to the tank, and pumping under pressure may increase potential leak rates on the transfer line and its components.

The use of a jet pump, as has been done in the past for single shell tank stabilization, increases the time required to pump (assumed to be up to two weeks) and has the potential for some unique leak scenarios on the waste transfer. These would be small leaks (essentially no pressure) that will drain in the pits before being sensed by the leak detectors. There can also be problems with leaks pooling on the surface or eroding depending on how the piping was laid (trench or berm).

4.1 MAJOR COMPONENT DESCRIPTIONS

The major components in the transfer system are:

- Pit leak detectors. This system is a simple set of probes connected to an electronic relay. If tripped, the relay will cause alarms and/or associated pump shutdown.
- Piping leak detectors. This system includes a single electrode probe connected to an electronic relay that will cause the pump to shutdown and leak alarms.
- Waste transfer pump. This component will be either the submersible pump or the jet pump.
- Waste transfer piping. The transfer piping includes an inner pipe surrounded by a pipe encasement. Some of the pipe encasements contain leak detectors, other piping is protected by the pit leak detector systems. All of the transfer piping is heat traced to prevent plugging during transfer.

4.2 NORMAL SYSTEM OPERATION

Normal operation of the tanks is storage of waste and does not include tank stabilization or transfer of liquids. This is a unique operation and will only occur once.

Several procedures must be completed prior to a transfer occurring. The major procedure is the Tank Farm Plant Operating Procedure TO-430-480, 244-TX DCRT TO 241-SY-102 TRANSFER VIA 244-S DCRT. This procedure applies to 244-TX DCRT, diversion boxes 241-TX-152, 241-U-152, 241-U-151, 244-S DCRT, SY-A valve pit, SY-02A central pump pit, tank 102-SY, catch tanks 241-U-301-B, 241-S-304, and the transfer lines (V402, V404, V422/V452, V456, V502, and SN277) associated with the route and associated valving and instrumentation. See Figure 1 for single line diagram of the transfer flow path.

Normal operation for the leak detectors is that the pit leak detectors are in service continuously. All transfer route leak detectors are verified as operable prior to the start of a transfer. If the leak detector or its associated components are inoperable, portable leak detectors may be used. Transfers may not progress until the route is protected by leak detectors.

9 2 1 2 7 9 0 7 5 4

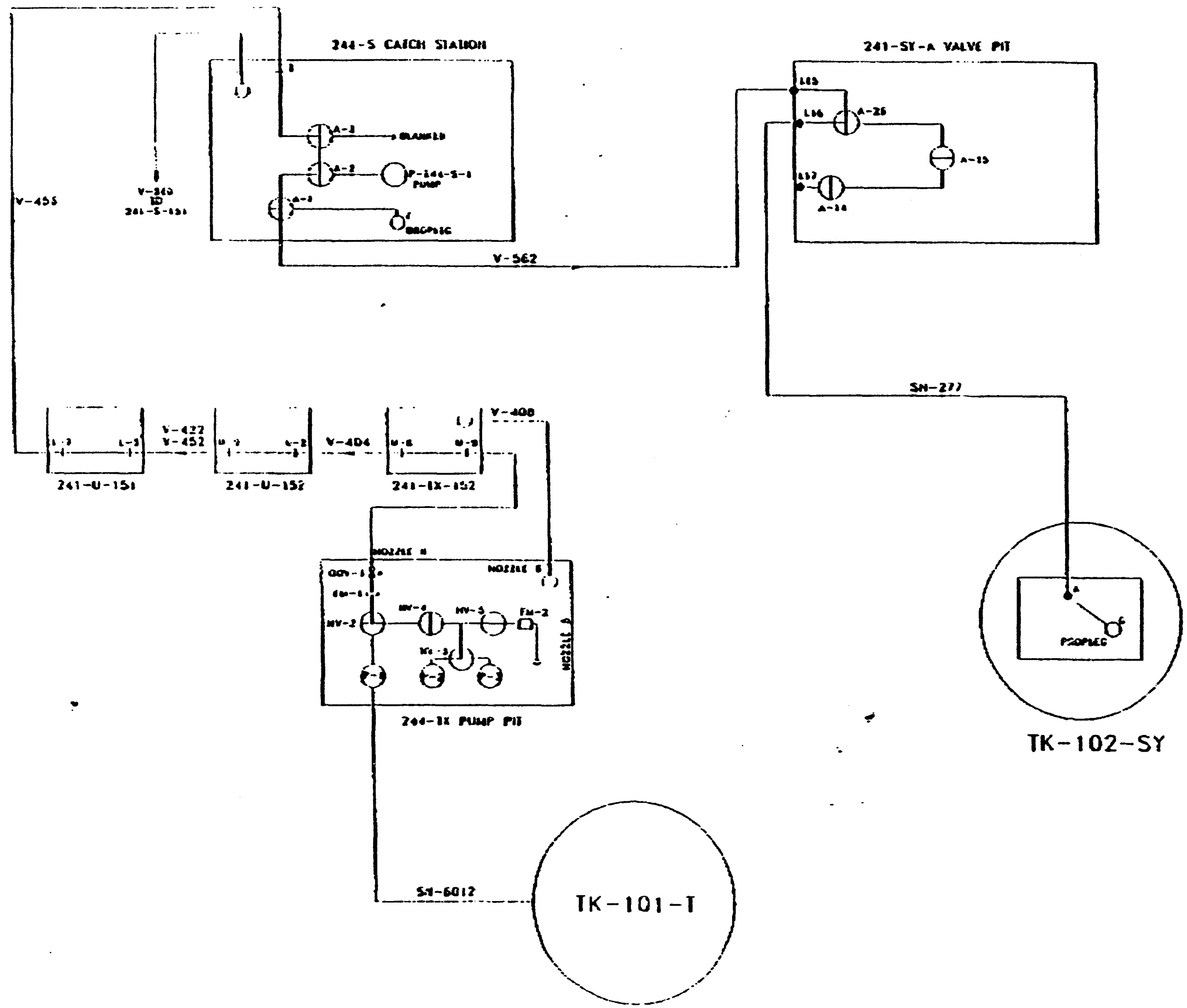


Figure 1 Transfer Pathway From TK-101-T to TK-102-SY

When the submersible pump is used, it is assumed that the leak rate will be sufficient to allow the leaking material to build up to the level to activate the detector. Most detectors are approximately an inch off the surface. In the case of the jet pump, the drains in the pits may collect the leaking material and avoid activating the leak detectors.

5.0 SAFETY CONSIDERATIONS

5.1 SUBMERSIBLE PUMP CONSIDERATIONS

The submersible pump is driven by 480 volt, three phase power and is protected by a 15 amp fuse. The motor for the pump is below the pump and is submersed in the liquid being pumped. Based on the pump SPECS, the pump undergoes a megger insulation test. Based on the required minimum resistance for the megger test and assuming the wiring connections are performed to the SPECS, it is assumed that no sparks are possible from the pump. This is further supplemented by the fact that the motor and pump are submersed in salt water which would conduct any power leakage to the grounded salt well. It is for these reasons that no spark will be able to ignite any flammable gases that might be present in the dome of the tank.

The submersible pump and motor are cooled by having a partial flow of the liquid being pumped pass by it. This is accomplished by having a sleeve surround the pump and motor. Water from the pump is forced down the sleeve cooling the surface. If some failure internal to the pump and motor were to cause excessive heat, the thermal switch on the power would open if it were functioning correctly. Most such internal failures would also draw excessive current and blow the fuse on the power line. The only reasonable source of excessive heat would be caused by the pump no longer having fluid to pump, but it continues to run. Even this condition would open the thermal overheat switch. The thermal switch is a bimetallic device where the two metals expand differently due to their different coefficients of expansion causing the switch to open and removing power to the pump motor. There is no flow meter on the output of the submersible pump. A material balance is calculated and recorded at least each hour to determine if the level in the 101-T tank is dropping in volume as rapidly as the volume in the 244-TX is increasing. This method is used to verify that the submersible pump is pumping. Therefore, the probability of adding excessive heat to the waste material in the 101-T tank is based on a human error (1.0E-03) and failure of the thermal switch to open (3.0E-05) or 3.0E-08 per transfer.

5.2 SN-6012 FAILURE

The pipe from the 101-T tank to the 244-TX pump pit is pipe SN-6012. It is not encased and is considered an old pipe run. It is 1800 feet long and bermed for coverage. In the report, "Accident Sequence Analysis For Safety

Assessment of Interim Stabilization of Non-Watch List Tanks", a similar pipe line was evaluated as an accident initiator in the following manner:

- 3.0E-07/hr ft x 640 ft x 8760 (hours per year) = 1.7/yr

In our case the evaluation would be as follows:

- 3.0E-07/hr ft x 1800 ft x 8760 (hours per year) = 4.7/yr

However, in this case, the transfer will only take 48 hours with the submersible pump. Therefore, the frequency will be 2.7E-02/transfer. To complete the sequence in the fashion of the study mentioned above, This initiator must be multiplied by failure of the first RAD detector to fail (3.5 E-03) or no detection (1.7E-03) and both of these results multiplied by none or boiling (9.2E-04). The results of this exercise are expressed below with their consequences:

9.45E-05/transfer	pool/spray
4.59E-05/transfer	max pool/spray
8.39E-08/transfer	pool/spray/vapor
4.22E-08/transfer	max pool/spray/pool

Even though the pipe line is much longer in this case, the frequency due to the limited transfer is approximately two orders of magnitude less than the referenced study for each consequence. If it is assumed that the leak is more in quantity, then the consequences might be more severe. The reference study limited the leak to 10,100 gallons. In this case of study, it is anticipated that the submersible pump will not pump at a rate higher than 20 gpm. At this rate, it would require over 8 hours to pump 10,100 gallons. But the mass balance is checked every hour. This will limit the potential leak rate to 1200 gallons per hour. If the jet pump is used, the frequencies above would increase by a factor of 7 making them closer to one order of magnitude less than the referenced study. The leak rate would be less than calculated for the submersible pump.

5.3 FAULT TREE ANALYSIS FOR TRANSFER FROM 244-TX to 102-SY

The top gate for the fault tree is P101 " UNDETECTED LEAK TO THE ENVIRONMENT OCCURS IN PATH FROM 244-TX to 102-SY TANK". This tree top was specifically developed to cover the transfer after either pump is used to remove the liquid from the 101-T tank. The fault tree includes initiating events such as "Leak from inner pipe of ____ while waste transfer to 102-SY occurs".

5.3.1 Assumptions and Modeling Bases

The fault tree model includes several assumptions important to the understanding of the model. These include:

1. The length of a waste transfer is assumed to be 48 hours, this is the mission time used for the fault tree quantification.

2. The leak detection systems are tested for operability before the start of the transfer. Therefore, no pre-existing failures are modeled.

3. The automatic response to several of the leak detectors is to trip their associated pump stopping the waste transfer and preventing a large spill. The failure of these pumps to trip when demanded is assumed a failure of the system.

4. The electric power and compressed air systems supporting the waste transfer system have been included in the fault tree for completeness, but the failure probability used is 0.

5.3.2 File Descriptions

The CAFTA code was used to generate, plot, and solve the fault trees. The CAFTA code is a microcomputer software which consists of a set of executable programs intended to be used in the development of Probabilistic Risk Assessments. The CAFTA program was developed by Science Applications International Corporation (SAIC). The computer program testing and acceptance report for this software is Reference 4. The CAFTA computer files generated during this analysis include the fault tree logic list, the gate description list, the basic event list, and the type code list. The Pump Failures Cause Added Heat to 101-T Tank or Undetected Leak to the Environment fault tree is provided in Appendix A. The corresponding basic event and type code files are provided in Appendix B.

The Type Code File (.TC) contains the generic failure rate data used in the quantification of the fault tree. The frequency of failure for a specific component is listed under the Rate Column. The reference source for that failure frequency is listed under the Source Column.

The Basic Event (.BE) file contains all of the basic events which are in the fault tree. There is a name, probability of failure, and description listed for each basic event. The probability of failure is calculated using the component type failure frequency from the type code file. If that failure rate is time dependent, then the probability of failure is a function of the rate and mission time length for the component. This has been assumed to be 48 hours for the transfer from 244-TX pump pit to the SY-102 tank, 48 hours for the submersible pump, and two weeks for the jet pump. If it is a demand failure, the probability of failure is a function of the failure per demand and the number of demands. The number of demands in this case is assumed to be one.

6.0 RESULTS AND CONCLUSIONS

The concepts of sparks occurring in the 101-T tank as a result of using a submersible pump have been dismissed. The possibility of this same pump over heating and causing excess heat in the 101-T tank has also been dismissed as being important to the consequences of draining the tank of liquids. The consequences and frequency of leak failures in the SN-6012 pipe from the 101-T tank have been compared to the stabilization study and found to be of less frequency and consequences. The remaining evaluation is to consider undetected leaks in the pathway from the 244-TX to the 102-SY tank. The fault tree quantification of this system will be discussed next.

Quantification is performed by solving the fault tree for cutsets. A cutset is an event or combination of events that lead to the top event or undesired state of the system. A discussion of the top cutsets is provided in this section. A listing of all cutsets including single and multiple element cutsets greater than 1.0E-10 is provided in a computer file in Appendix C.

6.1 GATE P101

This gate sums all of the undetected leak failures for the transfer system. There are 11 cutsets with a probability greater than 1.0E-06 per this transfer. The remaining cutsets are less. All 11 cutsets involve the failure of a leak detector element in conjunction with a leak. The first of these cutsets has a probability of 2.49E-05 per transfer. Leak detector LDE-02A-1 fails mechanically and the 102-SY-02A pump pit flex hose leaks. The next six cutsets are evaluated at 1.18E-05 per transfer. All six cutsets have a mechanical failure of a leak detector and an element leaking. The leaking elements and detectors are:

LEAKING ELEMENT	LEAK DETECTOR
102-SY-02A pump pit nozzle A	LDE-02A-1
244-S catch tank connector 3	LDE-PP-2A
244-S catch tank connector 3	LDE-PP-2
102-SY-02A pump pit nozzle G	LDE-02A-1
241-SY-A valve pit connector L-16	LDE-VP-SY-A
241-SY-A valve pit connector L-15	LDE-VP-SY-A

The next cutset is that the 102-SY-02A pump pit flex hose leaks and LDE-02A-1 is miscalibrated at 1.92E-06 per transfer. Cutsets 9 and 10 has the P-244-S-1 process pump seal leaking and LDE-PP-2A and LDE-02A-1 failing due to mechanical failure. These cutsets are evaluated at 1.87E-06 per transfer. The last cutset has the 102-SY-02A flex hose leaking and LDE-02A-1 probes corroded with a probability of 1.84E-06 per transfer. The remaining cutsets have a probability of 9.12E-07 per transfer or less.

Cutsets 61 and 62 are single cutsets that represent leaks in pipes V-422, and V-452. These two cutsets cover piping between diversion boxes 241-U-151 and 152. These pipes appear to not be encased and do not have leak detectors. If leaks occurred in these pipes, the only detection would be by the area CAMs and the leaks would be to the atmosphere rather than to the encasement. There are also flow meters in the path and the levels in the two ends are continuously evaluated. These two cutsets have been evaluated at 4.8E-08 each per transfer. The failure rate assumes that they will have passed a hydrostatic test before they are used. If they are not tested first some probability in the range of 1.3E-04 per transfer might be more appropriate. This evaluation is based on the same failure rate, but uses a mission time of 15 years, the approximate age of the piping.

6.2 RECOMMENDATIONS

To assure that this study falls within the limits expressed in the reference study[6], certain procedures must be followed. To avoid spray type releases, covers on equipment such as pump and valve pits must be secured and remain secured during the transfer. To avoid hydrogen fires in inclosed equipmemt areas such as tanks, ventilation systems must be functioning and potential sparking equipment must be kept at a minimum. The final recommendation is required to assure that the potential leak from the SN-6012 pipe is less than 10,100 gallons limit of reference[6] it will be necessary to require that the mass balance calculation be performed every hour of the transfer fron tank 101-T to the 244-TX pump pit.

7.0 REFERENCES

1. Process Engineering Department, "Waste Transfer and Routing Facilities Facility Description Manual", FDM-T-020-00002, Rev. A-0, Operating Documents Group, Process Engineering Department, Westinghouse Hanford Company, March 26, 1985.

2. Williamson, L. A., SD-WM-RA-001, "Risk Assessment Tank Farm Operation Mistransfers Descriptive Statistics and Probability", Westinghouse Hanford Company, February, 1990.

3. TO-025-001, Rev. D-5, "Plant Operating Procedure, Perform Tank Farm Transfer - General", January 27, 1992.

4. TO-430-480, Rev. E-1, "244-TX to 241-SY-102 Transfer Via 244-S DCRT, Prerelease".

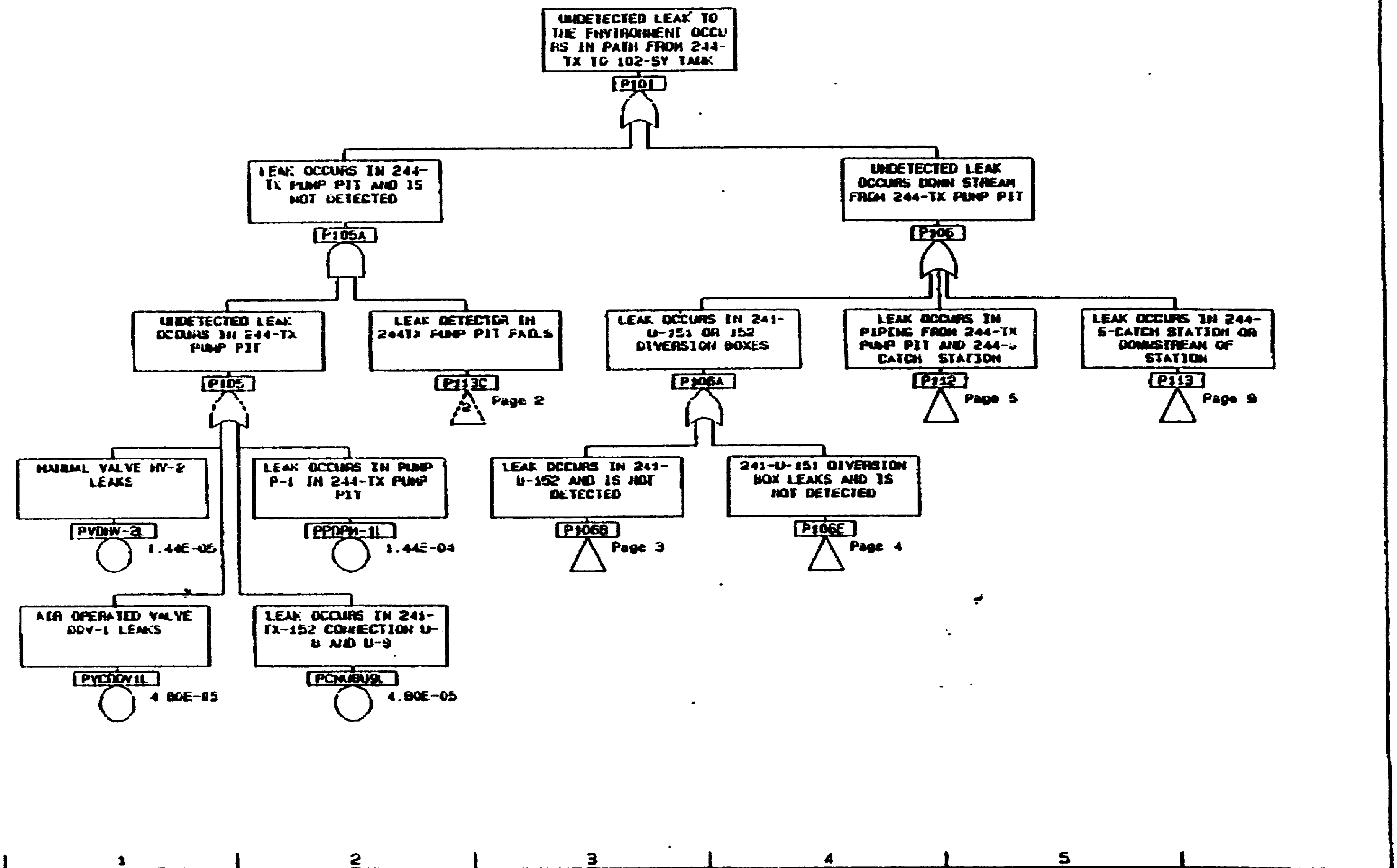
5. Powers, T. B., WHC-SD-MP-SWD-0004, Rev. 0-C, "CAFTA Computer Program Testing and Acceptance Report", Westinghouse Hanford Company, 1992.

6. Coles, G. A., Letter Report, Rev. 1, "Accident Sequence Analysis For Safety Assessment of Interim Stabilization of Non-Watch List Tanks", May 1992.

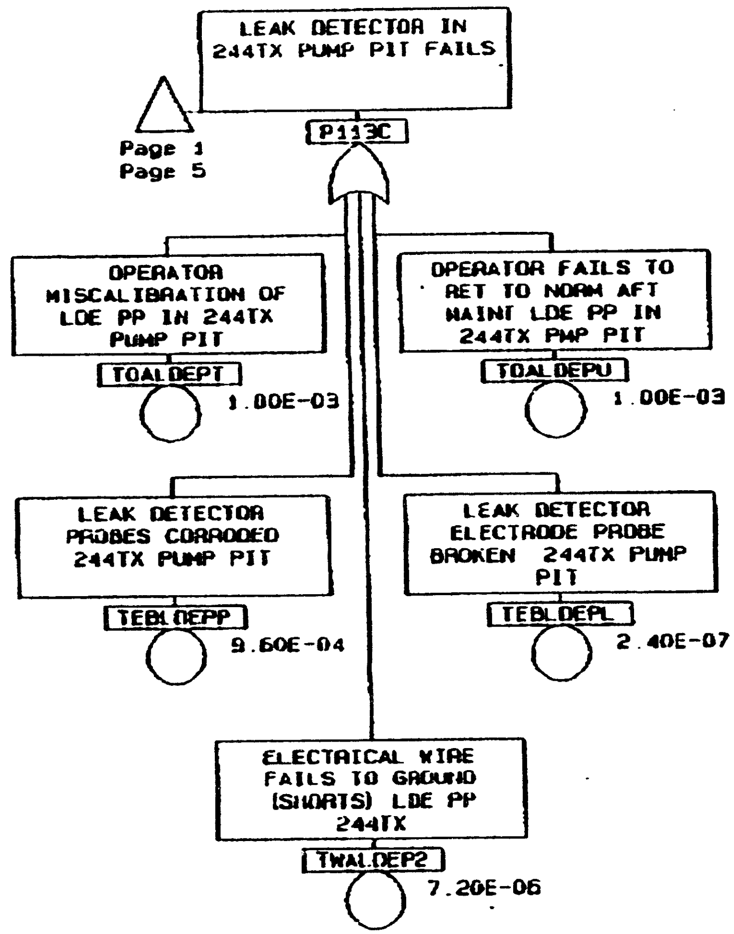
Drawings	Title
H-2-34965 Rev. 19 Sh 1 and 2 of 2	Leak Detector Assembly Typical Details
H-2-37732 Rev. 5	Electrical Site Plan
H-2-37734 Rev. 10	Elec Instr House Plan One Line Diag & Panelboard Schedules
H-2-37735 Rev. 4 Sh 1 and 2 of 2	Electrical Elementary Diagram
ECN 121986, 10/7/92	Rewire T101 Pump Controls
H-2-37736 Rev. 4	Electrical Details
H-2-37757 Rev. 5 Sh 1 and 2 of 2	Instrumentation Engineering Flow Diagram 241-SY Tanks 101, 102, & 103
H-2-37761 Rev. 4	Instrumentation Annunciator Elementary Diagram
H-2-37770 Rev. 5	Engineering Flow Diagram 242-SY Tank Farm Miscellaneous
H-2-37778 Rev. 5 sh 1 of 3	Piping Plan SY Tank Farm

APPENDIX A

FAULT TREE

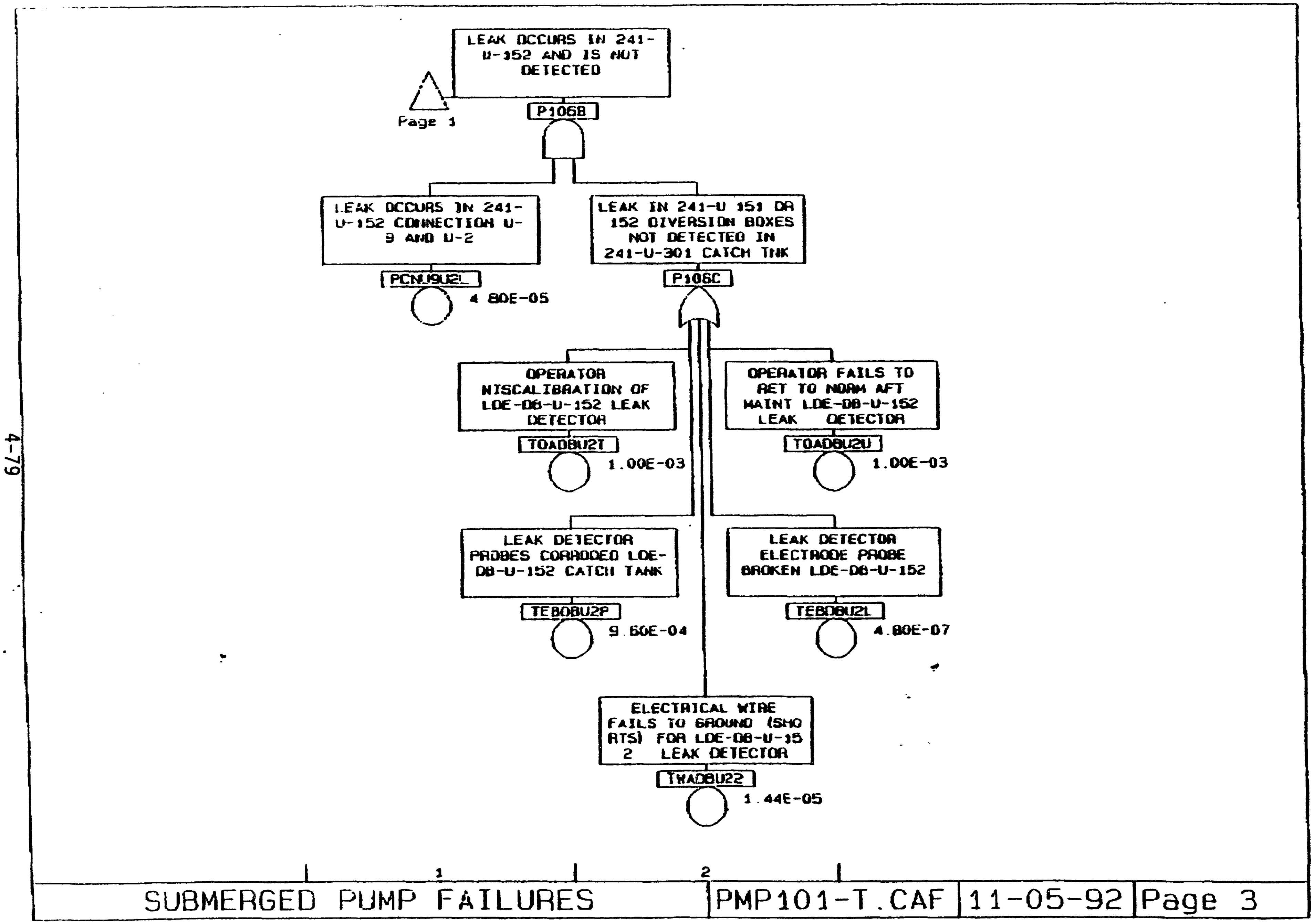


SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 1



1 2

SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 2



LEAK OCCURS IN 241-U-152 AND IS NOT DETECTED
Page 1
P106B
LEAK OCCURS IN 241-U-152 CONNECTION U-9 AND U-2
PCNU9U2L
4.80E-05
LEAK IN 241-U 151 OR 152 DIVERSION BOXES NOT DETECTED IN 241-U-301 CATCH TNK
P106C
OPERATOR MISCALIBRATION OF LDE-DB-U-152 LEAK DETECTOR
TOADBU2T
1.00E-03
OPERATOR FAILS TO RET TO NORM AFT MAINT LDE-DB-U-152 LEAK DETECTOR
TOADBU2U
1.00E-03
LEAK DETECTOR PROBES CORRODED LDE-DB-U-152 CATCH TANK
TEBDBU2P
9.60E-04
LEAK DETECTOR ELECTRODE PROBE BROKEN LDE-DB-U-152
TEBDBU2L
4.80E-07
ELECTRICAL WIRE FAILS TO GROUND (SHORTS) FOR LDE-DB-U-152 LEAK DETECTOR
TWADBU22
1.44E-05
1
2
SUBMERGED PUMP FAILURES
PMP101-T.CAF
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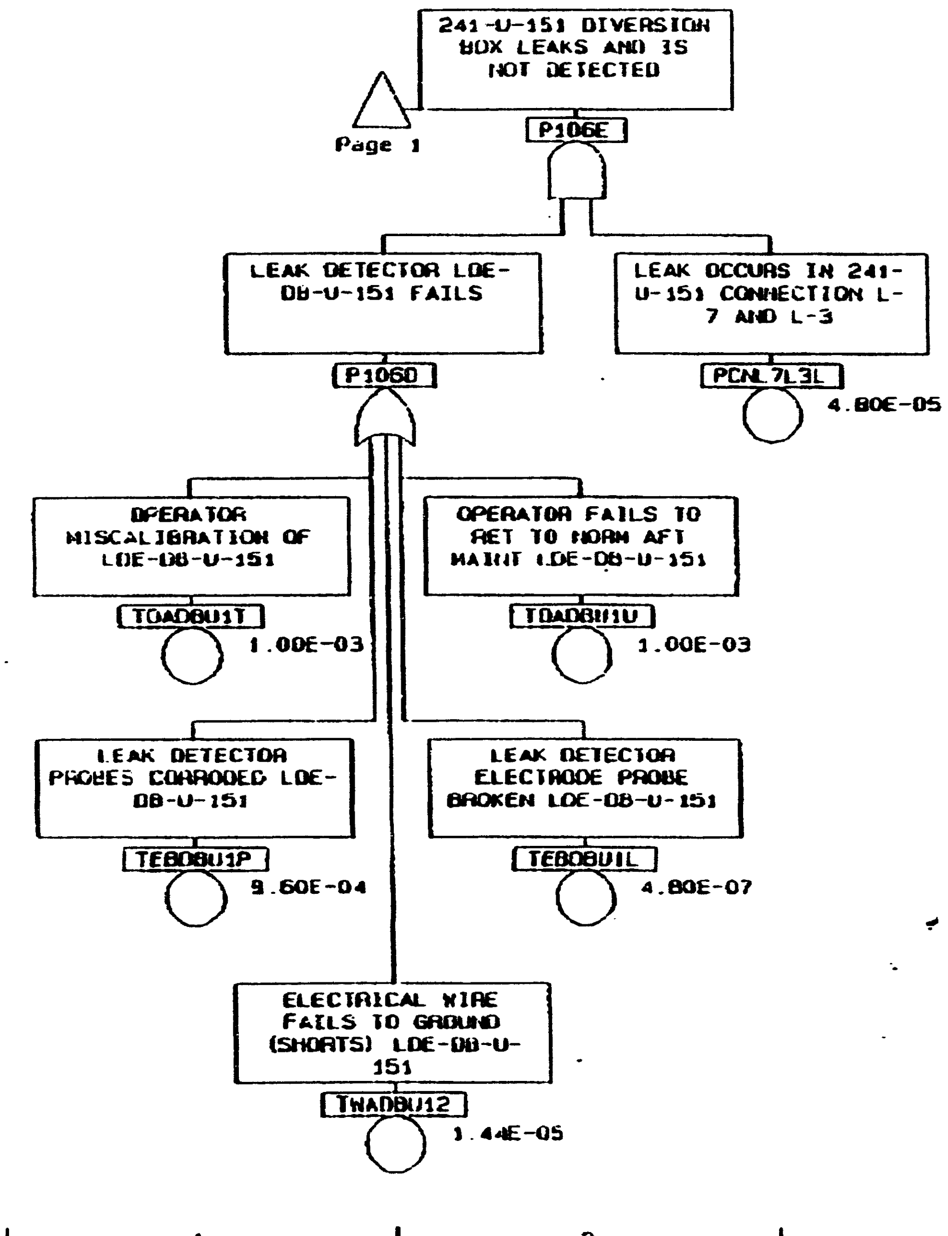
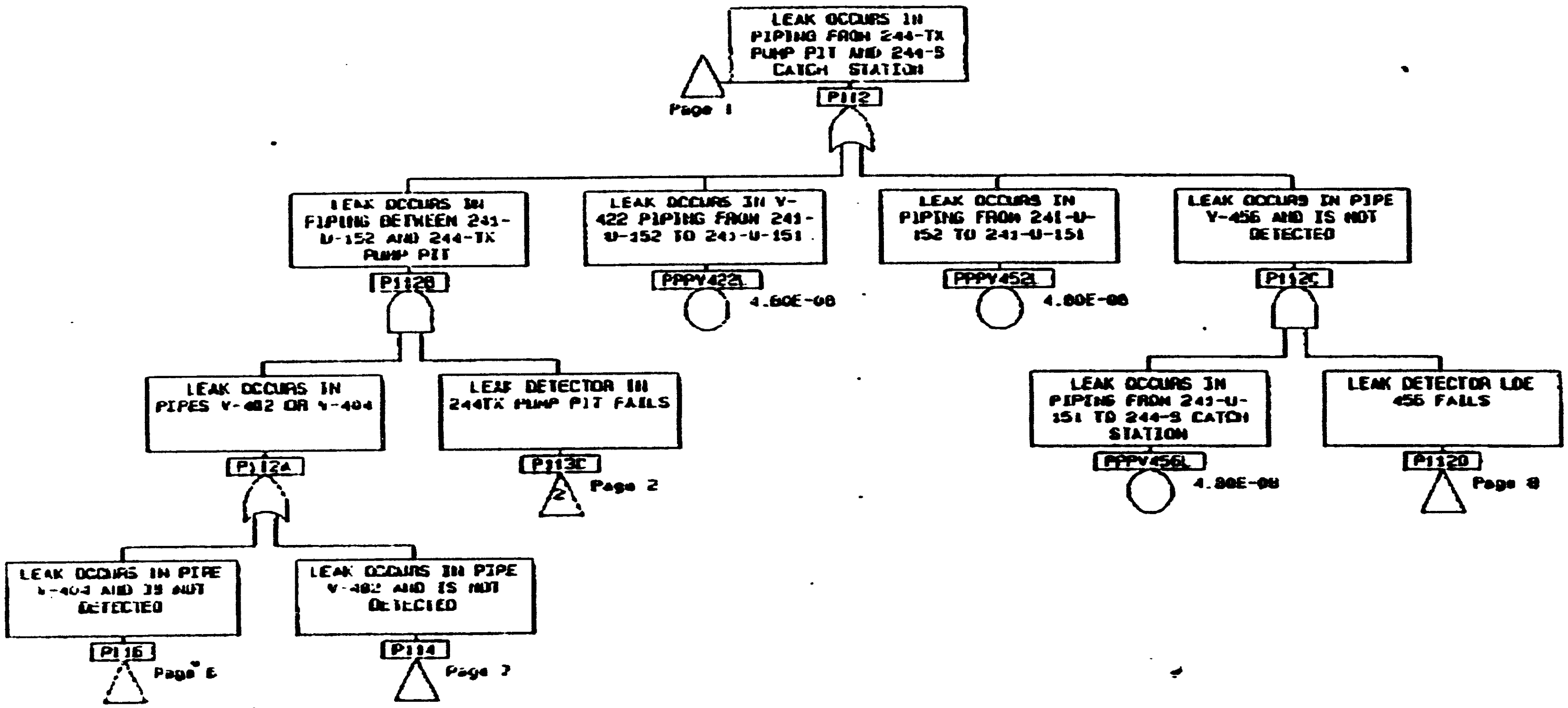
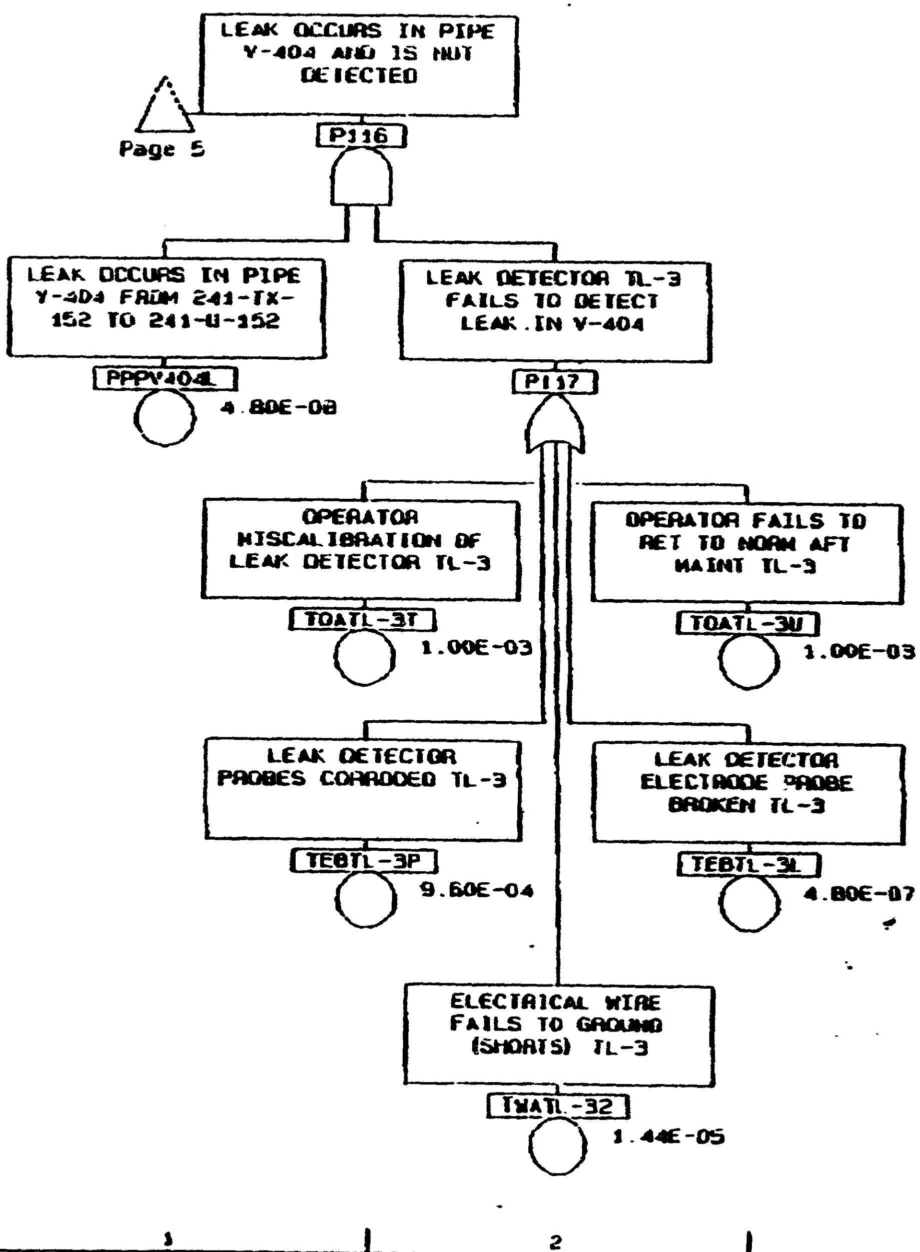


SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 4



1	2	3	4	5

SUBMERGED PUMP FAILURES | PMP101-T.CAF | 11-05-92 | Page 5



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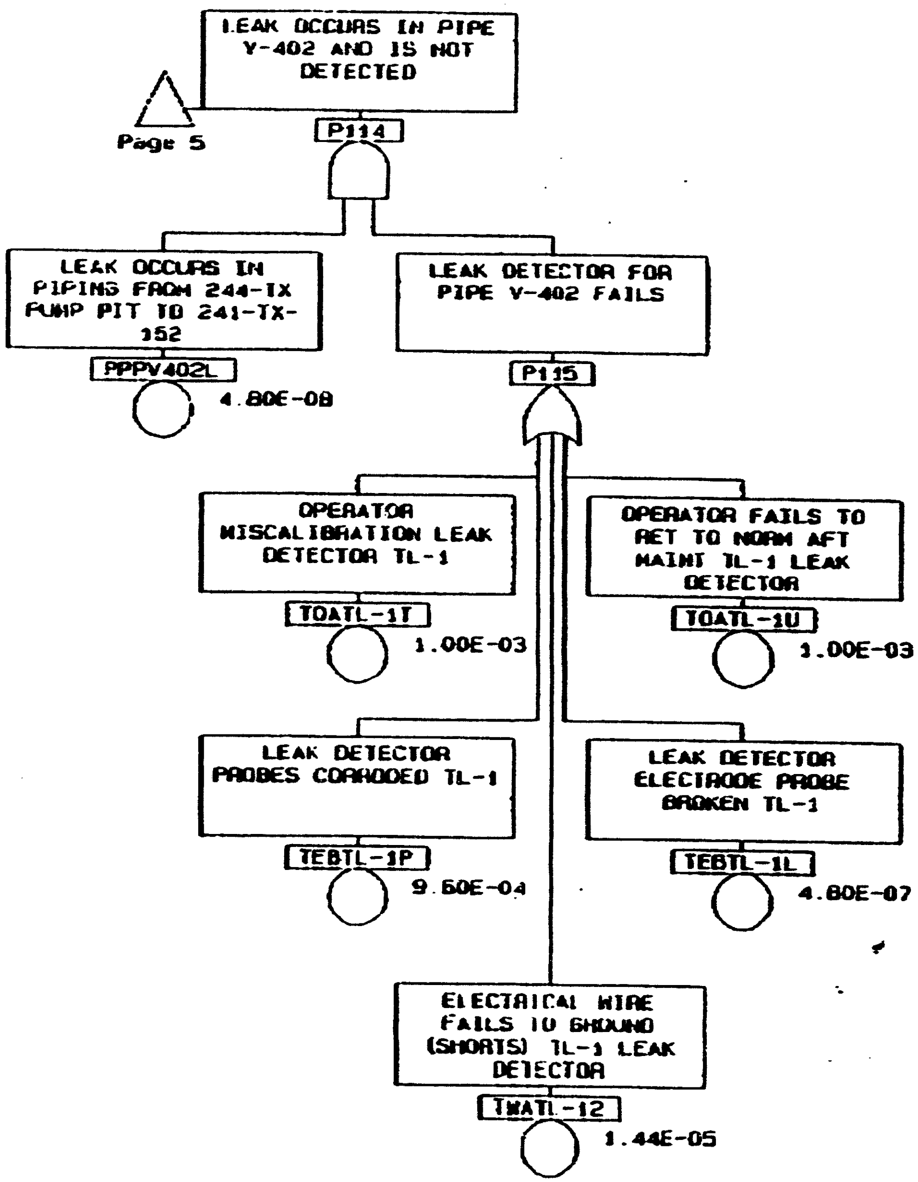
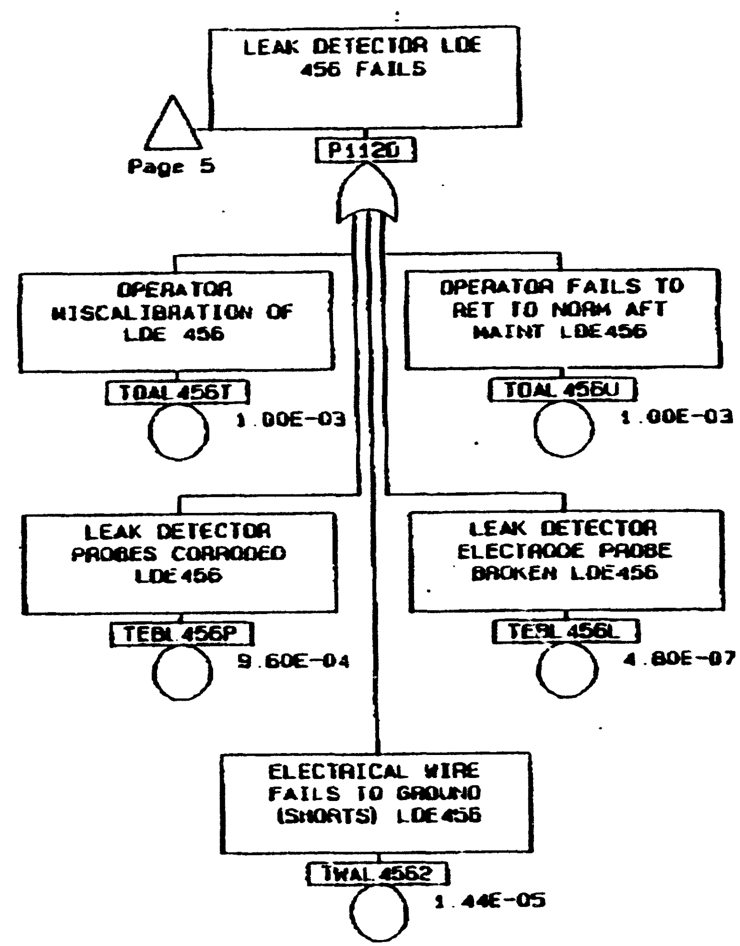
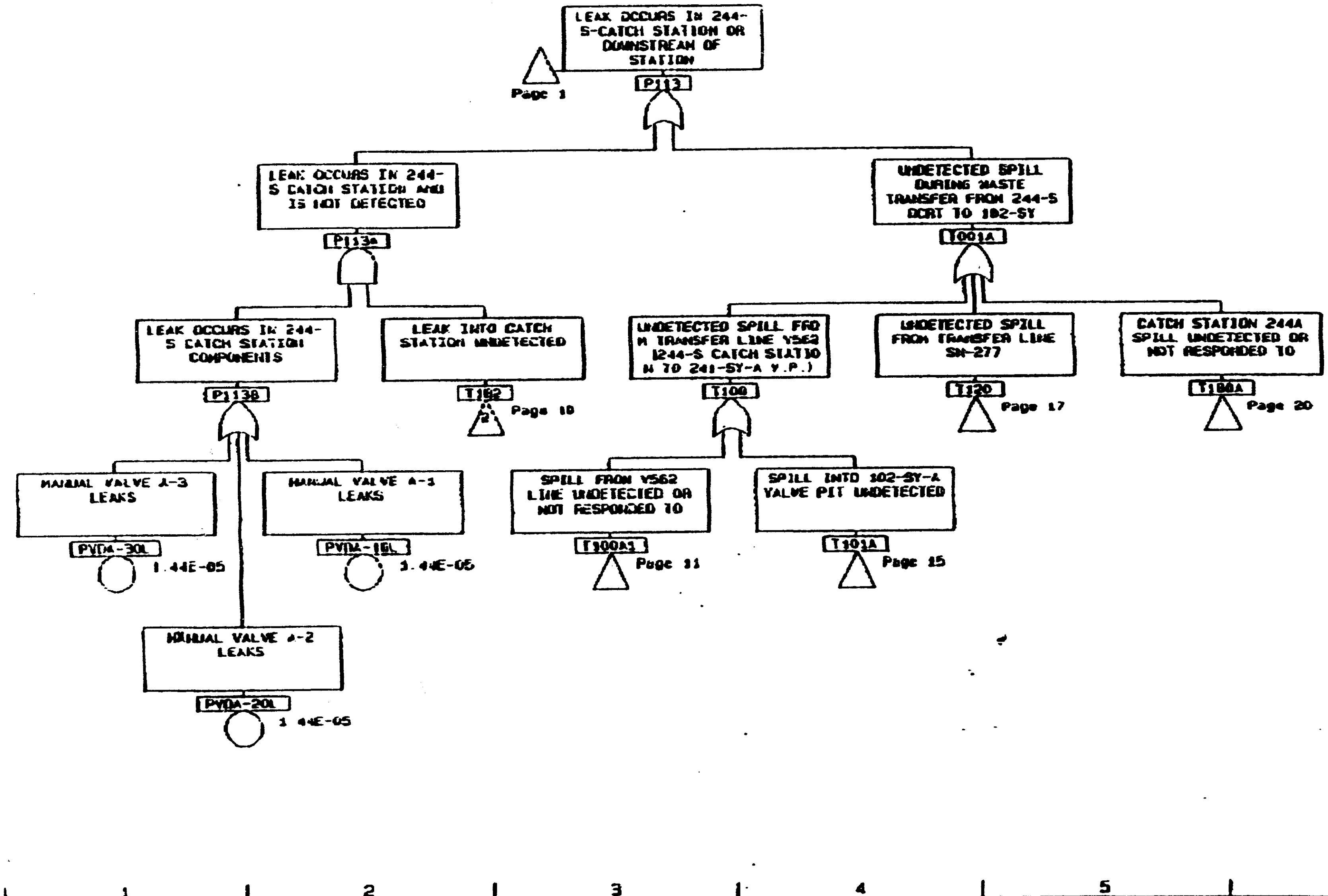


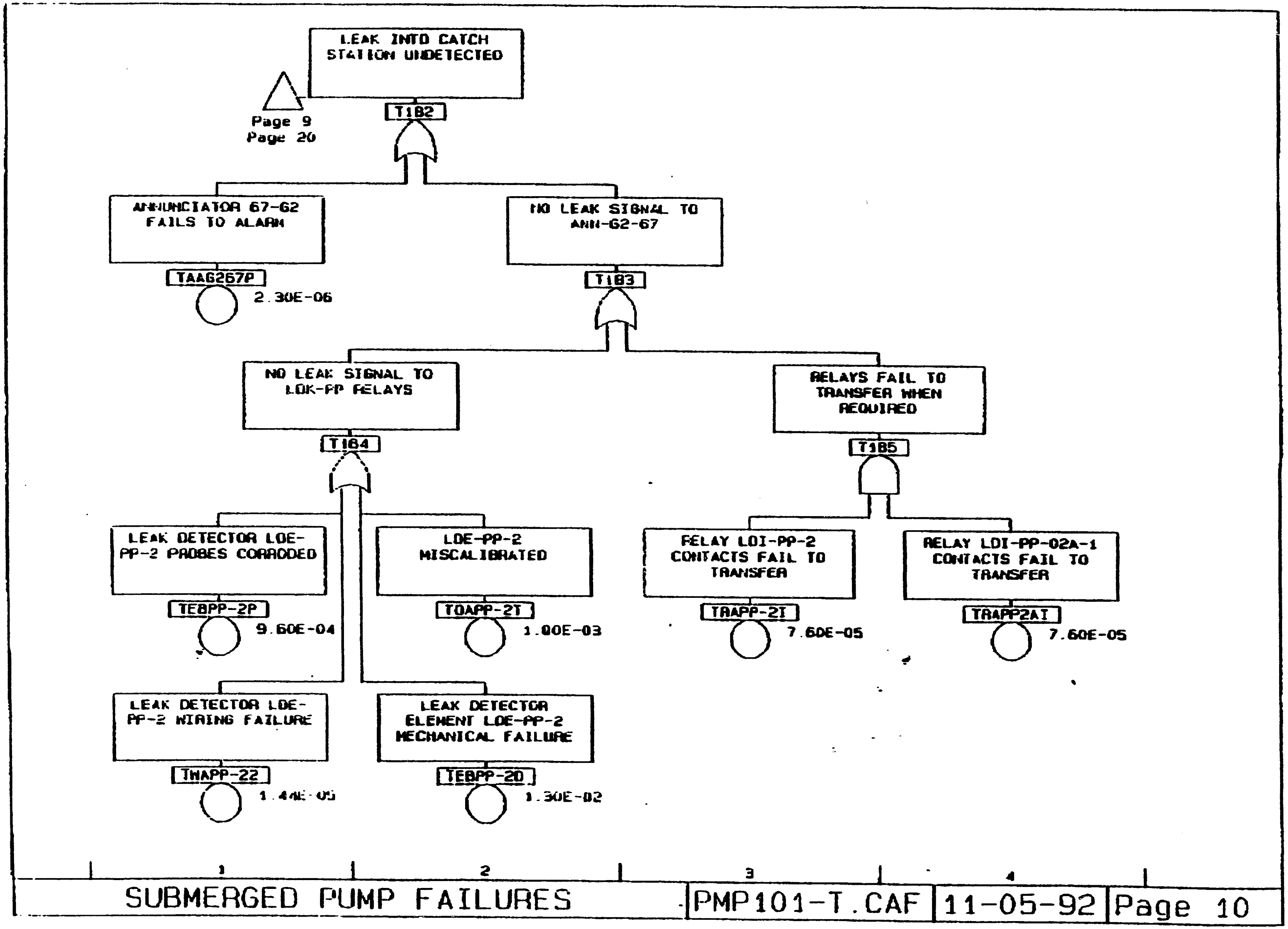
SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 7



SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 8



SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 9


LEAK INTO CATCH STATION UNDETECTED
T1B2
Page 9
Page 20
ANNUNCIATOR 67-62 FAILS TO ALARM
TAA6267P
2.30E-06
NO LEAK SIGNAL TO ANN-62-67
T1B3
NO LEAK SIGNAL TO LDK-PP RELAYS
T1B4
RELAYS FAIL TO TRANSFER WHEN REQUIRED
T1B5
LEAK DETECTOR LDE-PP-2 PROBES CORRODED
TEBPP-2P
9.60E-04
LDE-PP-2 MISCALIBRATED
TOAPP-2T
1.00E-03
RELAY LDI-PP-2 CONTACTS FAIL TO TRANSFER
TRAPP-2I
7.60E-05
RELAY LDI-PP-02A-1 CONTACTS FAIL TO TRANSFER
TRAPP2AI
7.60E-05
LEAK DETECTOR LDE-PP-2 WIRING FAILURE
TWAPP-22
1.44E-05
LEAK DETECTOR ELEMENT LDE-PP-2 MECHANICAL FAILURE
TEBPP-2D
1.30E-02
1
2
3
4
SUBMERGED PUMP FAILURES
PMP101-T.CAF
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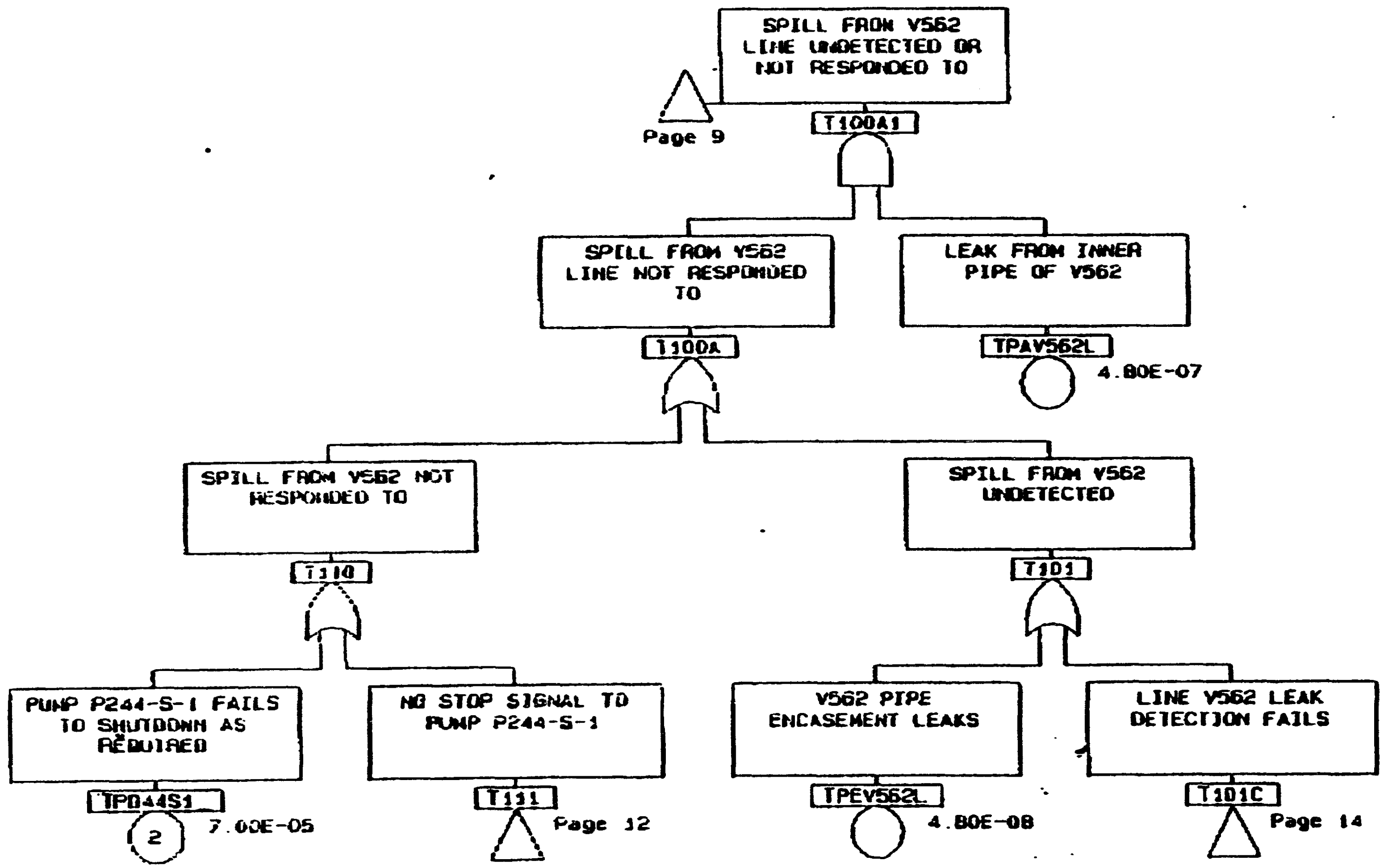
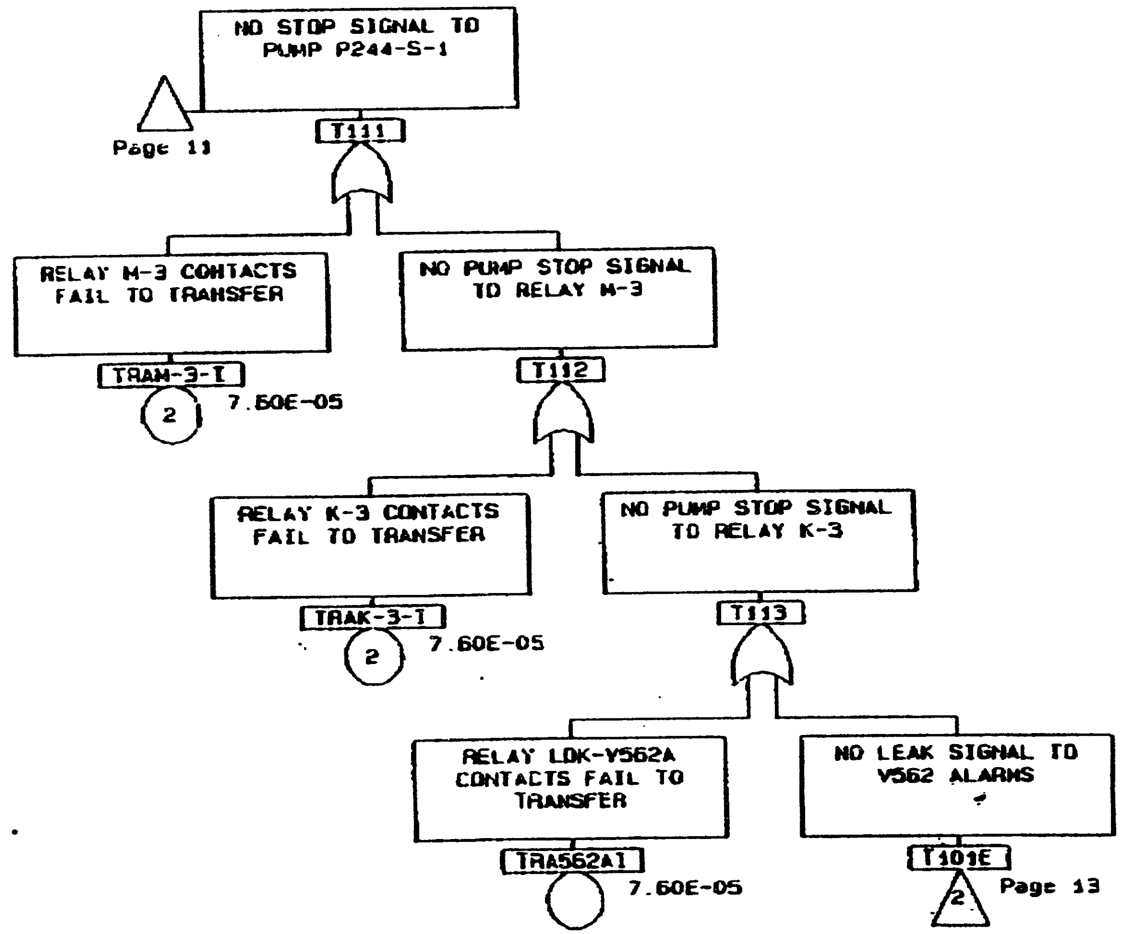
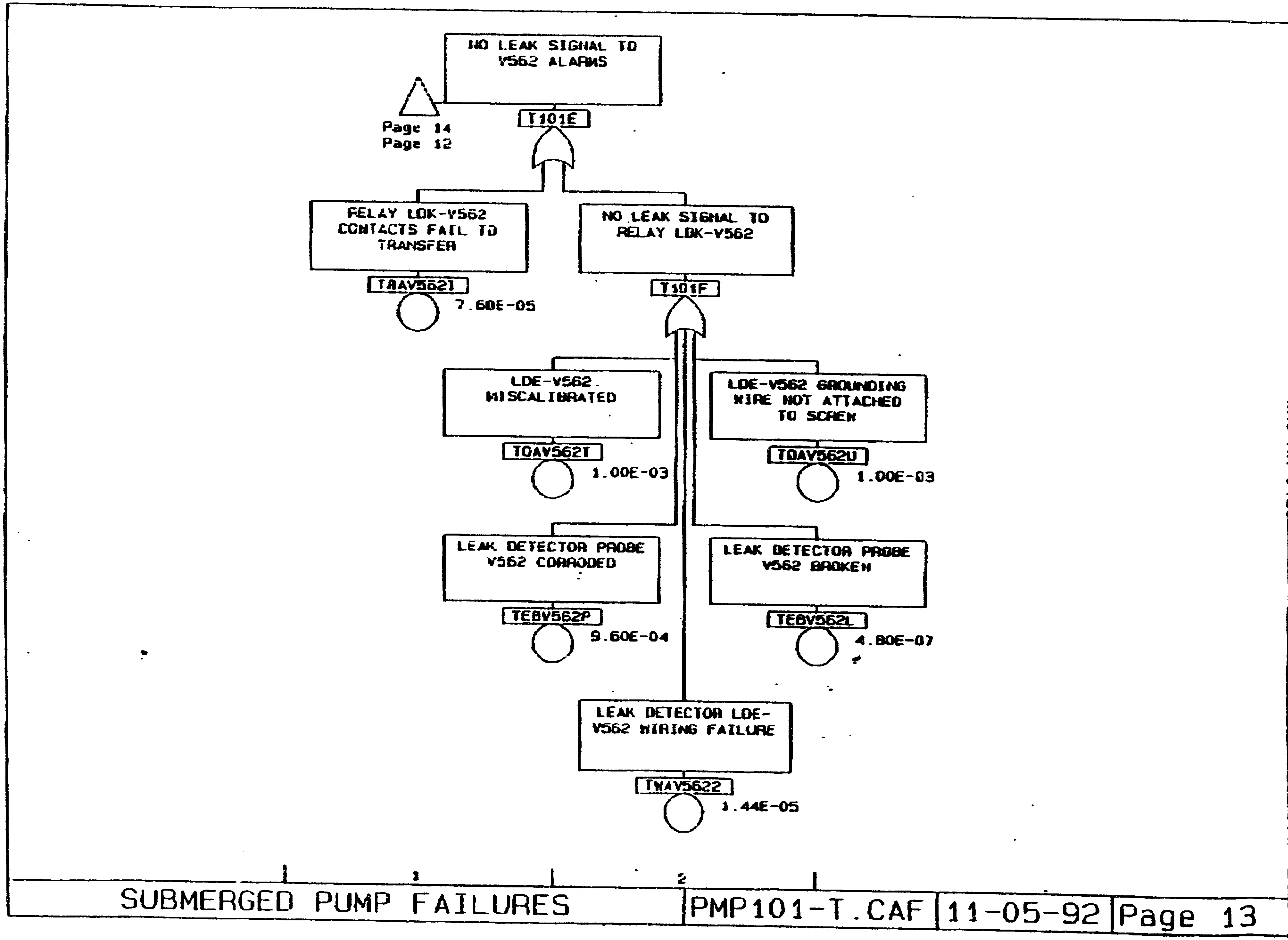
Page 10



SUBMERGED PUMP FAILURES | PMP101-T.CAF | 11-05-92 | Page 11


NO STOP SIGNAL TO PUMP P244-S-1
Page 11
T111
RELAY M-3 CONTACTS FAIL TO TRANSFER
TRAM-3-I
2
7.60E-05
NO PUMP STOP SIGNAL TO RELAY M-3
T112
RELAY K-3 CONTACTS FAIL TO TRANSFER
TRAK-3-I
2
7.60E-05
NO PUMP STOP SIGNAL TO RELAY K-3
T113
RELAY LDK-Y562A CONTACTS FAIL TO TRANSFER
TRA562AI
7.60E-05
NO LEAK SIGNAL TO V562 ALARMS
T101E
2
Page 13
1
2
3


NO LEAK SIGNAL TO V562 ALARMS
T101E
Page 14
Page 12
RELAY LDK-V562 CONTACTS FAIL TO TRANSFER
TRAV5621
7.60E-05
NO LEAK SIGNAL TO RELAY LDK-V562
T101F
LDE-V562 MISCALIBRATED
TOAV562T
1.00E-03
LDE-V562 GROUNDING WIRE NOT ATTACHED TO SCREW
TOAV562U
1.00E-03
LEAK DETECTOR PROBE V562 CORRODED
TEBV562P
9.60E-04
LEAK DETECTOR PROBE V562 BROKEN
TEBV562L
4.80E-07
LEAK DETECTOR LDE-V562 WIRING FAILURE
TWAV5622
1.44E-05
1
2
SUBMERGED PUMP FAILURES
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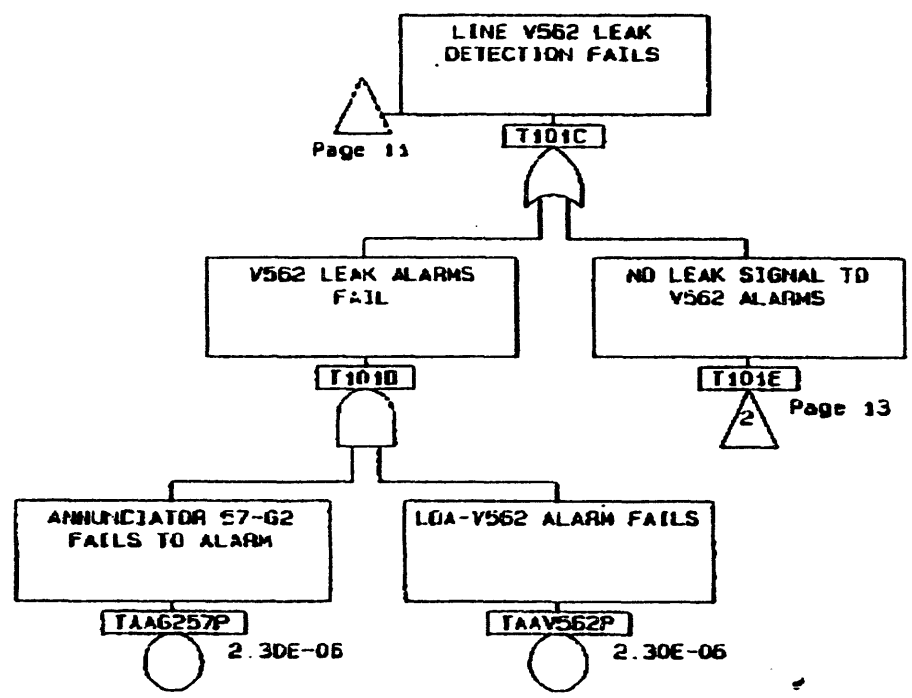
Page 13



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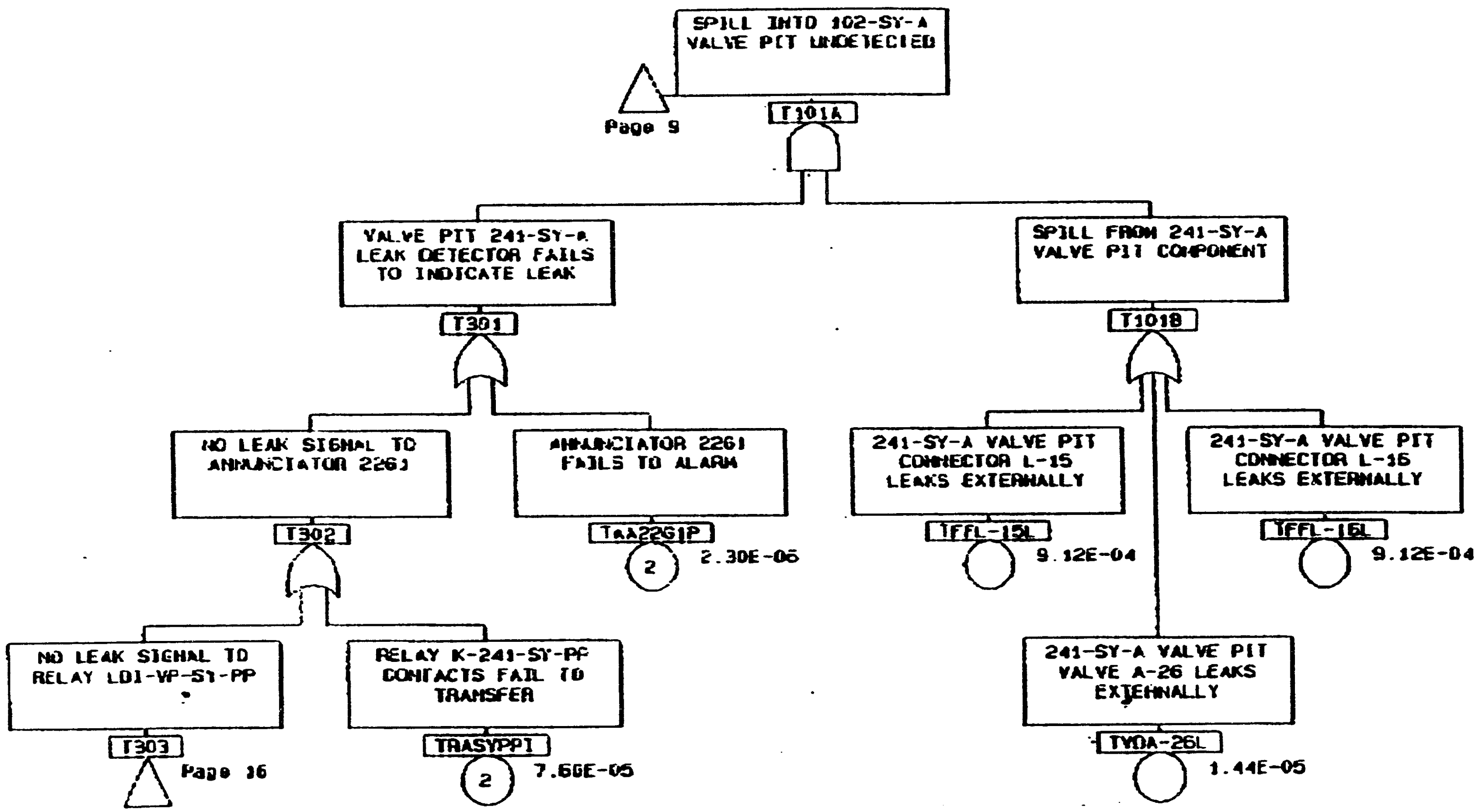
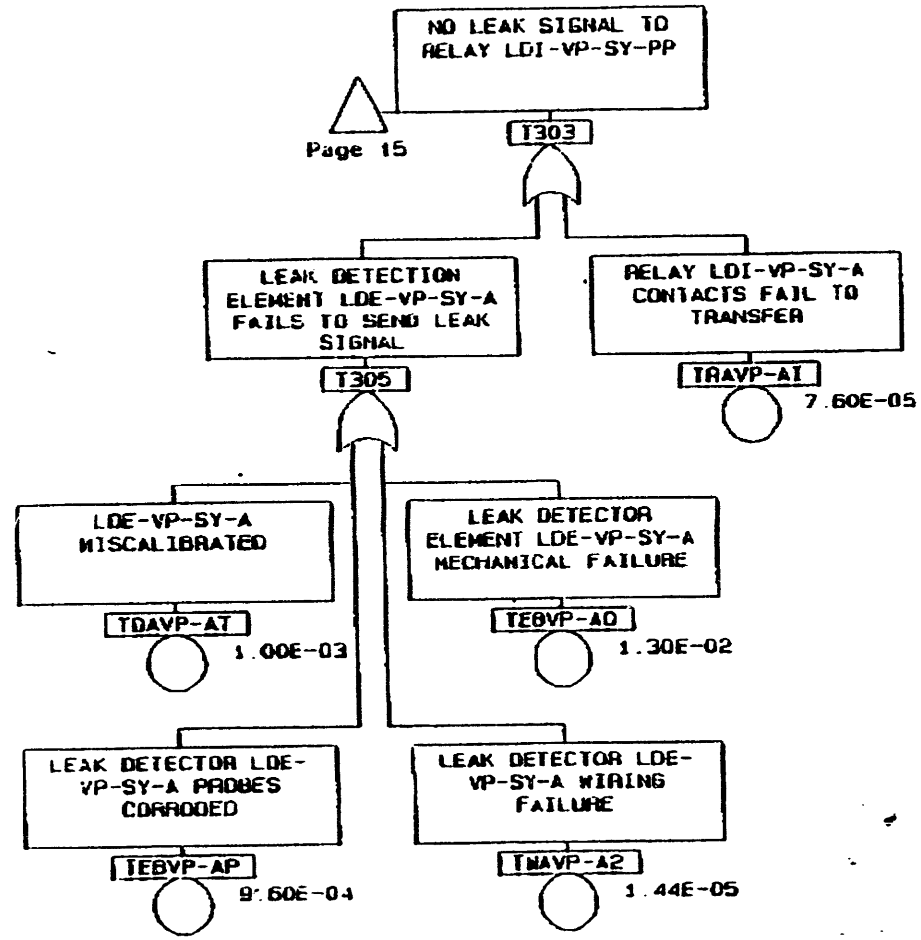
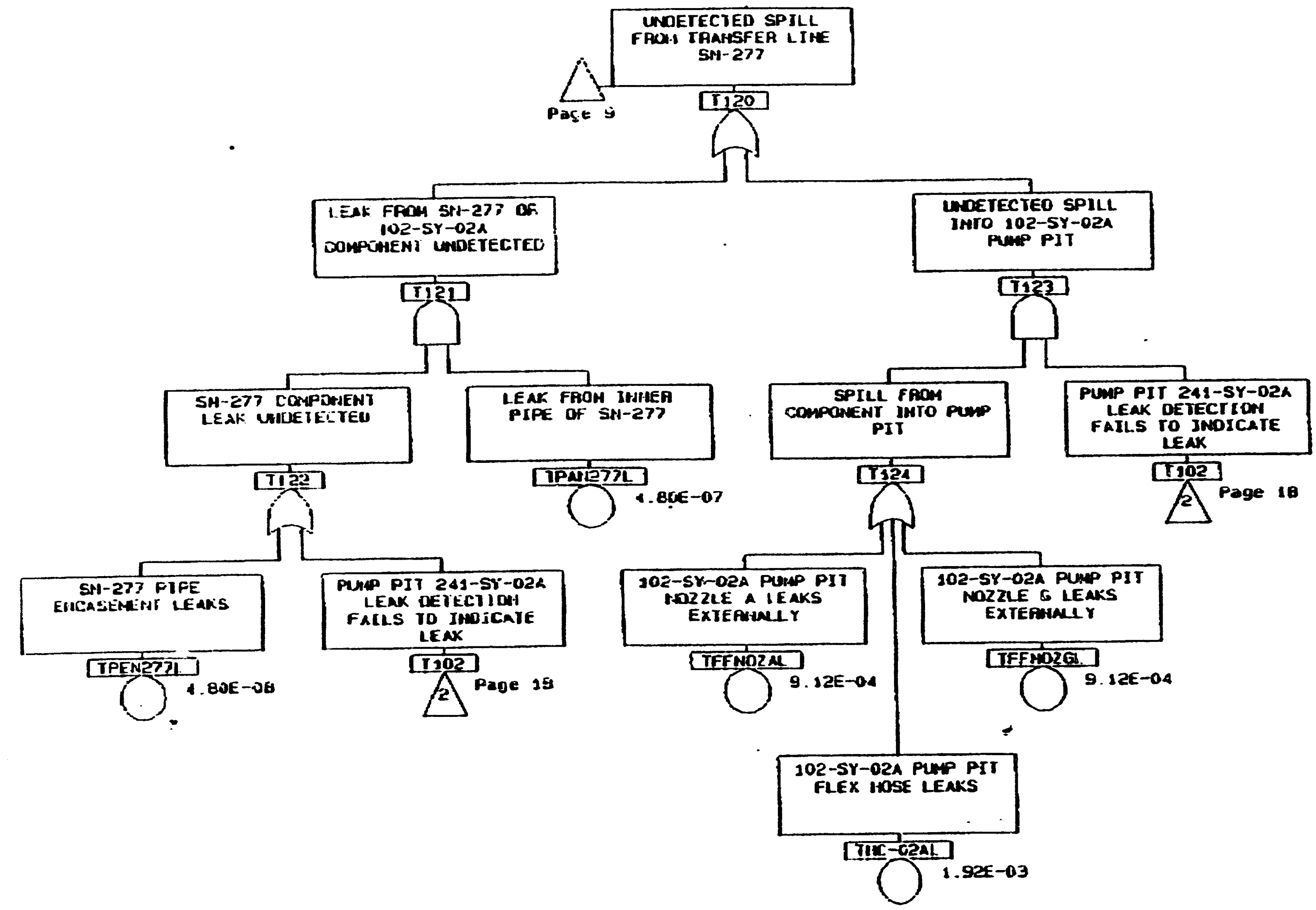


SUBMERGED PUMP FAILURES | PMP101-T.CAF | 11-05-92 | Page 15

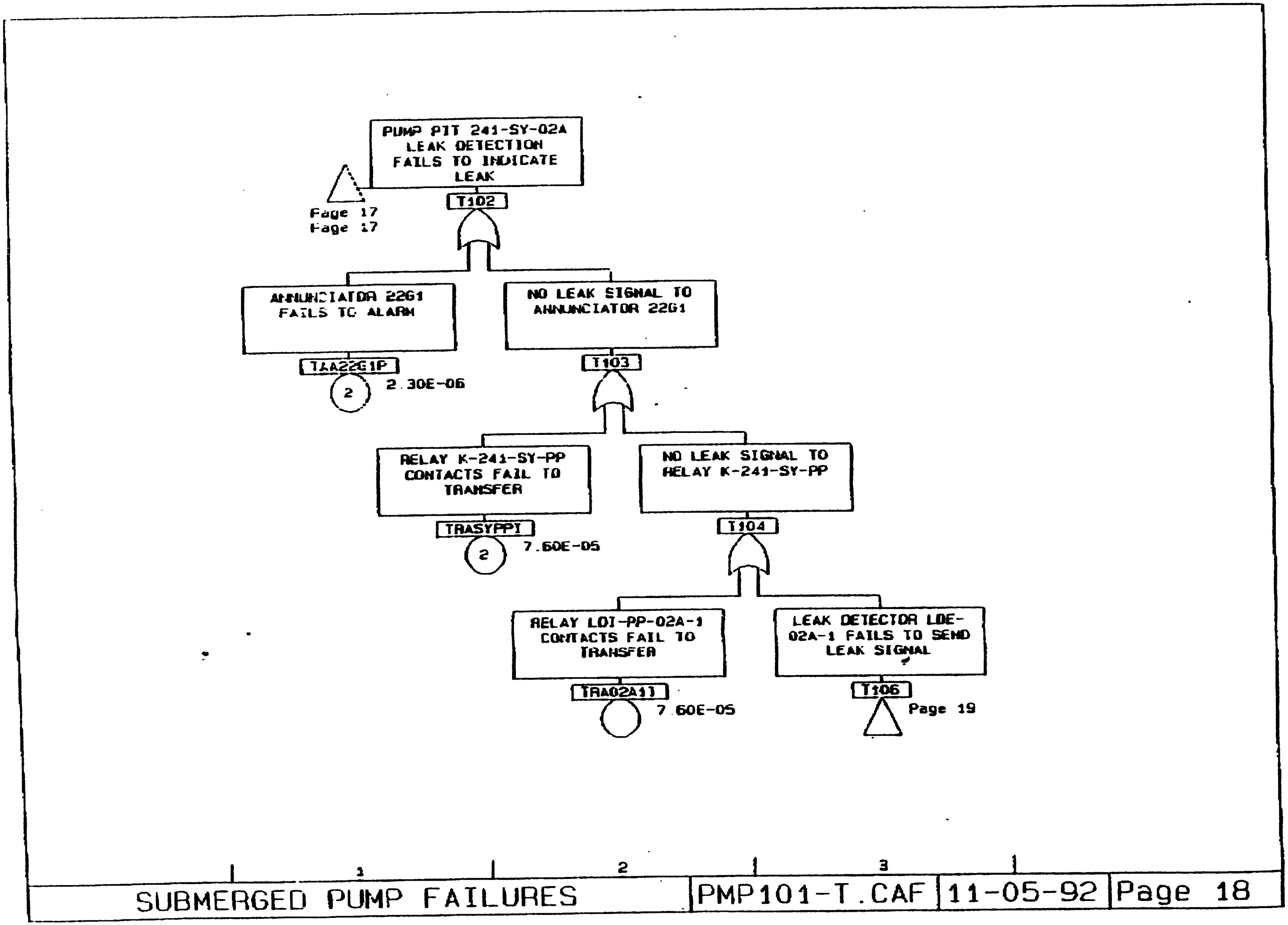


SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 16

9 2 1 2 7 7 9 1 7 7 3



SUBMERGED PUMP FAILURES | PMP101-T.CAF | 11-05-92 | Page 17


PUMP PIT 241-SY-02A LEAK DETECTION FAILS TO INDICATE LEAK
T102
Page 17
Page 17
ANNUNCIATOR 2261 FAILS TO ALARM
TAA2261P
2
2.30E-06
NO LEAK SIGNAL TO ANNUNCIATOR 2261
T103
RELAY K-241-SY-PP CONTACTS FAIL TO TRANSFER
TRASYPPI
2
7.60E-05
NO LEAK SIGNAL TO RELAY K-241-SY-PP
T104
RELAY LDI-PP-02A-1 CONTACTS FAIL TO TRANSFER
TRA02A11
7.60E-05
LEAK DETECTOR LDE-02A-1 FAILS TO SEND LEAK SIGNAL
T106
Page 19
1
2
3
SUBMERGED PUMP FAILURES
PMP101-T.CAF
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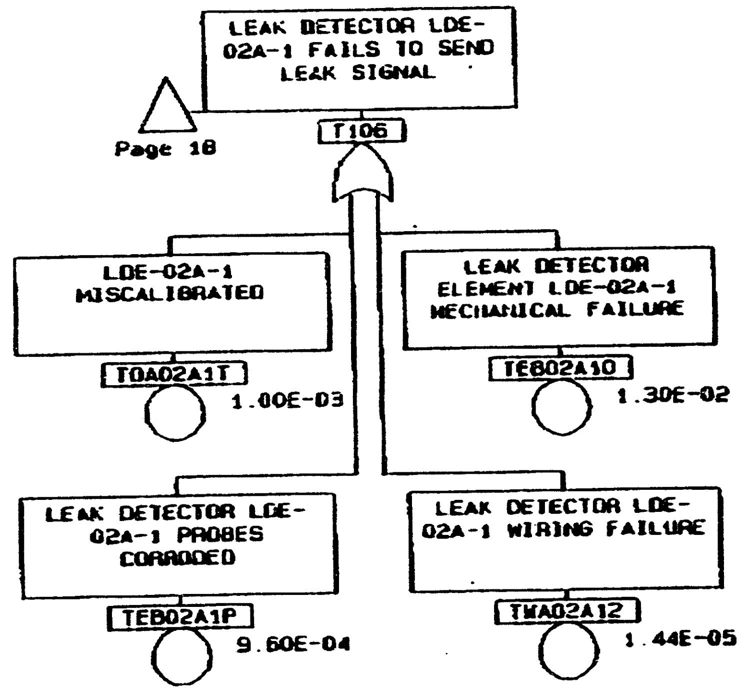
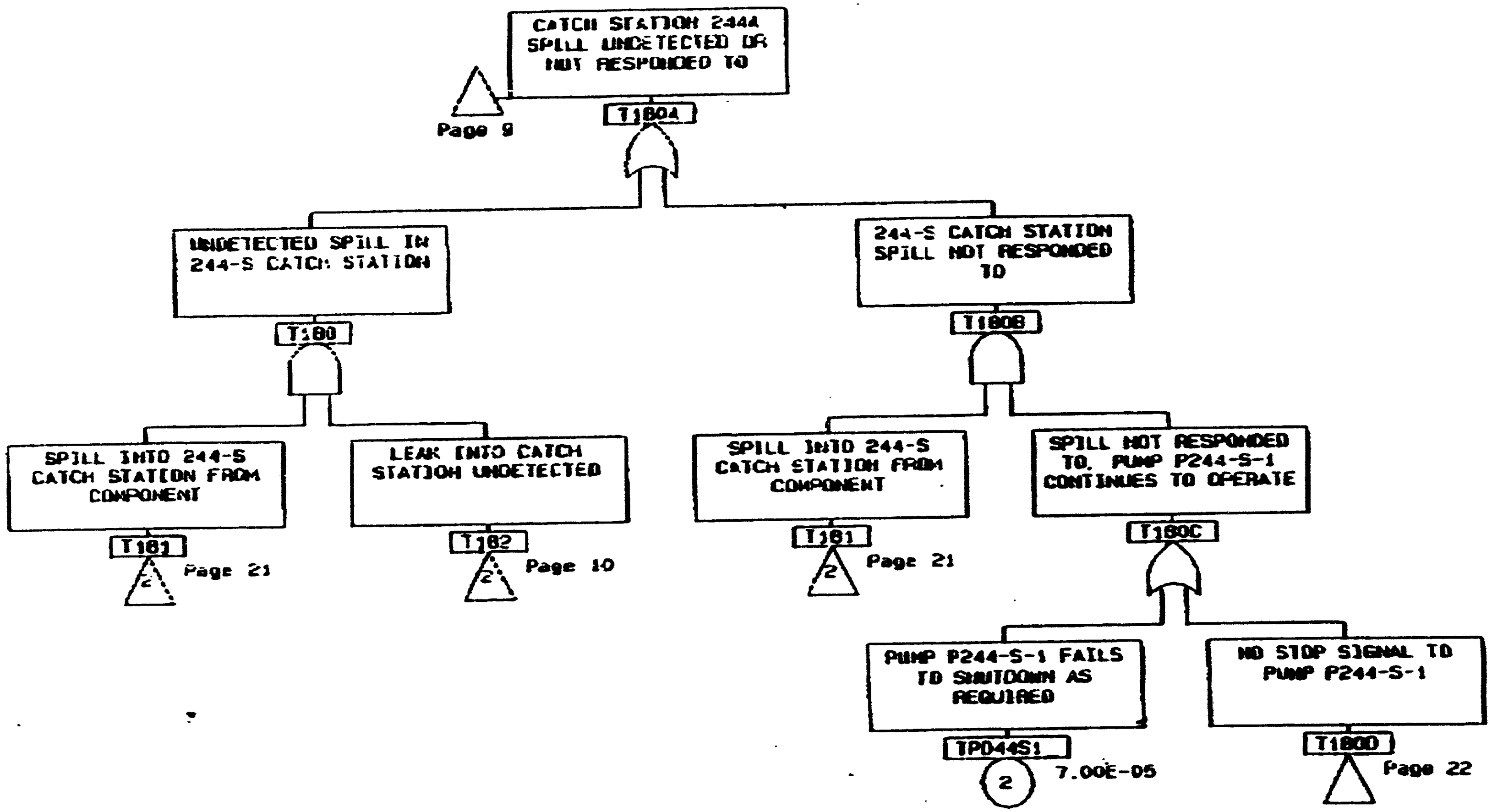
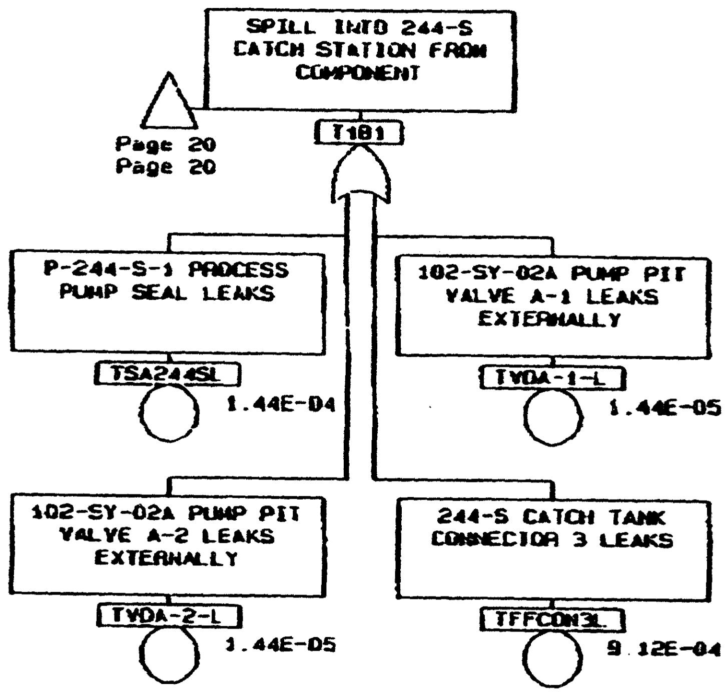
Page 18



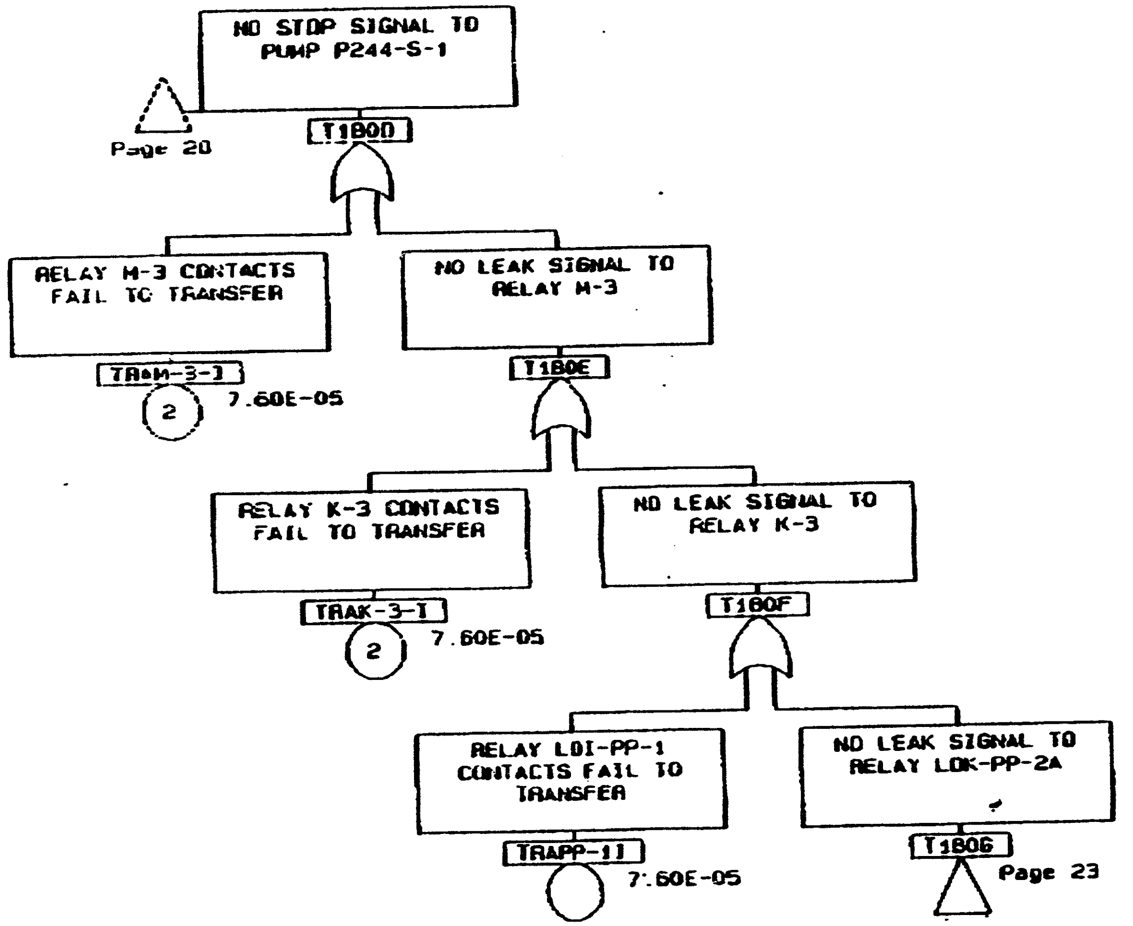
SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 19



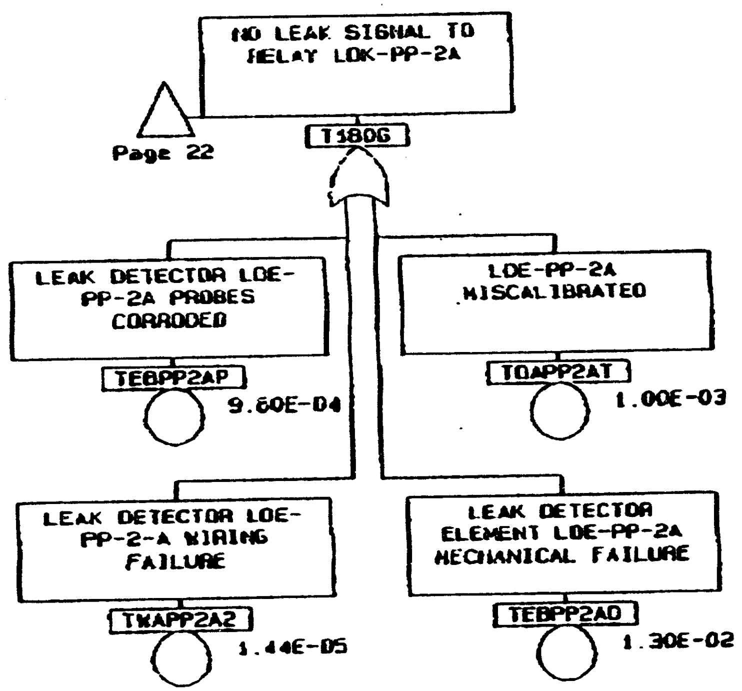
SUBMERGED PUMP FAILURES | PMP101-T.CAF | 11-05-92 | Page 20



SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 21



SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 22



SUBMERGED PUMP FAILURES	PMP101-T.CAF	11-05-92	Page 23

Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone	Gate/Event Name	Page	Zone
P101	1	3	T100A1	9	3	T183	10	2	TOALDEPT	2	1
P105	1	2	T100A1	11	3	T184	10	1	TOALDEPU	2	2
P105A	1	2	T101	11	4	T185	10	3	TOAPP-2T	10	2
P106	1	4	T101A	9	4	T301	15	2	TOAPP2AT	23	2
P106A	1	4	T101A	15	3	T302	15	2	TOATL-1T	7	1
P106B	1	3	T101B	15	4	T303	15	1	TOATL-1U	7	2
P106B	3	1	T101C	11	4	T303	16	2	TOATL-3T	6	1
P106C	3	2	T101C	14	2	T305	16	1	TOATL-3U	6	2
P106D	4	1	T101D	14	1	TAA22G1P	15	3	TOAV562T	13	1
P106E	1	4	T101E	12	3	TAA22G1P	18	1	TOAV562U	13	2
P106E	4	2	T101E	13	1	TAAG257P	14	1	TOAVP-AT	16	1
P112	1	5	T101E	14	2	TAAG267P	10	1	TPAN277L	17	3
P112	5	4	T101F	13	2	TAAV562P	14	2	TPAV562L	11	4
P112A	5	2	T102	17	2	TEB02A1D	19	2	TPD44S1_	11	1
P112B	5	2	T102	17	5	TEB02A1P	19	1	TPD44S1_	20	3
P112C	5	5	T102	18	1	TEBDBU1L	4	2	TPEN277L	17	1
P112D	5	6	T103	18	2	TEBDBU1P	4	1	TPEV562L	11	3
P112D	8	1	T104	18	2	TEBDBU2L	3	2	TRA02A1I	18	2
P113	1	6	T106	18	3	TEBDBU2P	3	1	TRA562AI	12	2
P113	9	3	T106	19	1	TEBL456L	8	2	TRAK-3-I	12	1
P113A	9	2	T110	11	2	TEBL456P	8	1	TRAK-3-I	22	1
P113B	9	2	T111	11	2	TEBLDEPL	2	2	TRAN-3-I	12	1
P113C	1	3	T111	12	1	TEBLDEPP	2	1	TRAN-3-I	22	1
P113C	2	1	T112	12	2	TEBPP-2D	10	2	TRAPP-1I	22	2
P113C	5	3	T113	12	2	TEBPP-2P	10	1	TRAPP-2I	10	3
P114	5	2	T120	9	5	TEBPP2AD	23	2	TRAPP2AI	10	4
P114	7	1	T120	17	3	TEBPP2AP	23	1	TRASYPPI	15	2
P115	7	2	T121	17	2	TEBTL-1L	7	2	TRASYPPI	18	1
P116	5	1	T122	17	2	TEBTL-1P	7	1	TRAV562I	13	1
P116	6.	1	T123	17	4	TEBTL-3L	6	2	TRAVP-AI	16	2
P117	6	2	T124	17	4	TEBTL-3P	6	1	TSA244SL	21	1
PCHL7L3L	4	2	T180	20	1	TEBV562L	13	2	TVDA-1-L	21	2
PCNU8U9L	1	2	T180A	9	6	TEBV562P	13	1	TVDA-2-L	21	1
PCNU9U2L	3	1	T180A	20	2	TEBVP-AD	16	2	TVDA-26L	15	4
PPDPM-1L	1	2	T180B	20	3	TEBVP-AP	16	1	TWA02A12	19	2
PPPV402L	7	1	T180C	20	4	TFFCON3L	21	2	TWADBU12	4	1
PPPV404L	6	1	T180D	20	4	TFFL-15L	15	4	TWADBU22	3	2
PPPV422L	5	3	T180D	22	1	TFEL-16L	15	5	TWAL4562	8	1
PPPV452L	5	4	T180E	22	2	TFFNOZAL	17	3	TWALDEP2	2	1
PPPV456L	5	5	T180F	22	2	TFFNOZGL	17	4	TWAPP-22	10	1
PVCDOV1L	1	1	T180G	22	3	THC-02AL	17	4	TWAPP2A2	23	1
PVDA-10L	9	2	T180G	23	1	TOA02A1T	19	1	TWATL-12	7	2
PVDA-20L	9	2	T181	20	1	TOADBU1T	4	1	TWATL-32	6	2
PVDA-30I	9	1	T181	20	3	TOADBU1U	4	2	TWAV5622	13	2
PVDHV-2L	1	1	T181	21	1	TOADBU2T	3	1	TWAVP-A2	16	2
T001A	9	4	T182	9	3	TOADBU2U	3	2			
T100	9	4	T182	10	2	TOAL456T	8	1			
T100A	11	3	T182	20	2	TOAL456U	8	2			

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APPENDIX B

BASIC EVENT AND TYPE CODE FILES

	NAME	C	FACTOR	U	DESC	TR	SO	LOCAT	S	PROB
1	PCNL7L3L	1	4	H	LEAK OCCURS IN 241-U-151 CONNECTION L-7 AND L-3	P				4.80E-05
2	PCNU8U9L	1	4	H	LEAK OCCURS IN 241-TX-152 CONNECTION U-8 AND U-9	P				4.80E-05
3	PCNU9U2L	1	4	H	LEAK OCCURS IN 241-U-152 CONNECTION U-9 AND U-2	P				4.80E-05
4	PPOPM-1L	1	4	H	LEAK OCCURS IN PUMP P-1 IN 244-TX PUMP PIT	P				1.44E-04
5	PPP6012L	1	4	H	LEAK OCCURS IN SN-6012 PIPING FROM 101-T TANK PUMP PIT TO 244-TX DCRT	P				4.80E-08
6	PPPSALTP		1.0E-0		PUMP OVERHEATS DUE TO PUMPING AIR CAUSED BY OPERATOR ERROR OR WELL PLUGGING	P			U	1.00E-03
7	PPPSALTR		1.0E-0		PUMP OVERHEATS DUE TO PUMPING SLUDGE	P			U	1.00E-06
8	PPPV402L	1	4	H	LEAK OCCURS IN PIPING FROM 244-TX PUMP PIT TO 241-TX-152	P				4.80E-08
9	PPPV404L	1	4	H	LEAK OCCURS IN PIPE V-404 FROM 241-TX-152 TO 241-U-152	P				4.80E-08
10	PPPV422L	1	4	H	LEAK OCCURS IN V-422 PIPING FROM 241-U-152 TO 241-U-151	P				4.80E-08
11	PPPV452L	1	4	H	LEAK OCCURS IN PIPING FROM 241-U-152 TO 241-U-151	P				4.80E-08
12	PPPV456L	1	4	H	LEAK OCCURS IN PIPING FROM 241-U-151 TO 244-S CATCH STATION	P				4.80E-08
13	PSC0001I	1		H	OVERHEAT CONTROLS FAIL TO OPEN ON DEMAND	P				3.00E-05
14	PVCDOV1L	1	4	H	AIR OPERATED VALVE DOV-1 LEAKS	P				4.80E-05
15	PVDA-10L	1	4	H	MANUAL VALVE A-1 LEAKS	P				1.44E-05
16	PVDA-20L	1	4	H	MANUAL VALVE A-2 LEAKS	P				1.44E-05
17	PVDA-30L	1	4	H	MANUAL VALVE A-3 LEAKS	P				1.44E-05
18	PVDHV-2L	1	4	H	MANUAL VALVE HV-2 LEAKS	P				1.44E-05
19	TAA22G1P	1		H	ANNUNCIATOR 22G1 FAILS TO ALARM	P				2.30E-06
20	TAAG257P	1		H	ANNUNCIATOR 57-G2 FAILS TO ALARM	P				2.30E-06
21	TAAG267P	1		H	ANNUNCIATOR 67-G2 FAILS TO ALARM	P				2.30E-06
22	TAAV562P	1		H	LDA-V562 ALARM FAILS	P				2.30E-06
23	TEB02A1O	1	4	H	LEAK DETECTOR ELEMENT LDE-02A-1 MECHANICAL FAILURE	P				1.30E-02
24	TEB02A1P	1	4	H	LEAK DETECTOR LDE-02A-1 PROBES CORRODED	P				9.60E-04
25	TEB08U1L	1	4	H	LEAK DETECTOR ELECTRODE PROBE BROKEN LDE-08-U-151	P				4.80E-07
26	TEB08U1P	1	4	H	LEAK DETECTOR PROBES CORRODED LDE-08-U-151	P				9.60E-04
27	TEB08U2L	1	4	H	LEAK DETECTOR ELECTRODE PROBE BROKEN LDE-08-U-152	P				4.80E-07
28	TEB08U2P	1	4	H	LEAK DETECTOR PROBES CORRODED LDE-08-U-152 CATCH TANK	P				9.60E-04
29	TEBL456L	1	4	H	LEAK DETECTOR ELECTRODE PROBE BROKEN LDE456	P				4.80E-07
30	TEBL456P	1	4	H	LEAK DETECTOR PROBES CORRODED LDE456	P				9.60E-04
31	TEBLDEPL	1	2	H	LEAK DETECTOR ELECTRODE PROBE BROKEN 244TX PUMP PIT	P				2.40E-07
32	TEBLDEPP	1	4	H	LEAK DETECTOR PROBES CORRODED 244TX PUMP PIT	P				9.60E-04
33	TEBPP-2O	1	4	H	LEAK DETECTOR ELEMENT LDE-PP-2 MECHANICAL FAILURE	P				1.30E-02
34	TEBPP-2P	1	4	H	LEAK DETECTOR LDE-PP-2 PROBES CORRODED	P				9.60E-04
35	TEBPP2AO	1	4	H	LEAK DETECTOR ELEMENT LDE-PP-2A MECHANICAL FAILURE	P				1.30E-02
36	TEBPP2AP	1	4	H	LEAK DETECTOR LDE-PP-2A PROBES CORRODED	P				9.60E-04
37	TEBTL-1L	1	4	H	LEAK DETECTOR ELECTRODE PROBE BROKEN TL-1	P				4.80E-07
38	TEBTL-1P	1	4	H	LEAK DETECTOR PROBES CORRODED TL-1	P				9.60E-04
39	TEBTL-3L	1	4	H	LEAK DETECTOR ELECTRODE PROBE BROKEN TL-3	P				4.80E-07
40	TEBTL-3P	1	4	H	LEAK DETECTOR PROBES CORRODED TL-3	P				9.60E-04
41	TEBV562L	1	4	H	LEAK DETECTOR PROBE V562 BROKEN	P				4.80E-07
42	TEBV562P	1	4	H	LEAK DETECTOR PROBE V562 CORRODED	P				9.60E-04
43	TEBVP-AO	1	4	H	LEAK DETECTOR ELEMENT LDE-VP-SY-A MECHANICAL FAILURE	P				1.30E-02
44	TEBVP-AP	1	4	H	LEAK DETECTOR LDE-VP-SY-A PROBES CORRODED	P				9.60E-04
45	TFFCON3L	1	4	H	244-S CATCH TANK CONNECTOR 3 LEAKS	P				9.12E-04
46	TFFL-15L	1	4	H	241-SY-A VALVE PIT CONNECTOR L-15 LEAKS EXTERNALLY	P				9.12E-04
47	TFFL-16L	1	4	H	241-SY-A VALVE PIT CONNECTOR L-16 LEAKS EXTERNALLY	P				9.12E-04
48	TFFNOZAL	1	4	H	102-SY-02A PUMP PIT NOZZLE A LEAKS EXTERNALLY	P				9.12E-04
49	TFFNOZGL	1	4	H	102-SY-02A PUMP PIT NOZZLE G LEAKS EXTERNALLY	P				9.12E-04
50	THC-02AL	1	4	H	102-SY-02A PUMP PIT FLEX HOSE LEAKS	P				1.92E-03
51	TOA02A1T	1		H	LDE-02A-1 MISCALIBRATED	P				1.00E-03
52	TOA08U1T	1		H	OPERATOR MISCALIBRATION OF LDE-08-U-151	P				1.00E-03
53	TOA08U1U	1		H	OPERATOR FAILS TO RET TO NORM AFT MAINT LDE-08-U-151	P				1.00E-03
54	TOA08U2T	1		H	OPERATOR MISCALIBRATION OF LDE-08-U-152 LEAK DETECTOR	P				1.00E-03
55	TOA08U2U	1		H	OPERATOR FAILS TO RET TO NORM AFT MAINT LDE-08-U-152 LEAK DETECTOR	P				1.00E-03
56	TOAL456T	1		H	OPERATOR MISCALIBRATION OF LDE 456	P				1.00E-03
57	TOAL456U	1		H	OPERATOR FAILS TO RET TO NORM AFT MAINT LDE456	P				1.00E-03
58	TOALDEPT	1		H	OPERATOR MISCALIBRATION OF LDE PP IN 244TX PUMP PIT	P				1.00E-03
59	TOALDEPU	1		H	OPERATOR FAILS TO RET TO NORM AFT MAINT LDE PP IN 244TX PMP PIT	P				1.00E-03
60	TOAPP-2T	1		H	LDE-PP-2 MISCALIBRATED	P				1.00E-03
61	TOAPP2AT	1		H	LDE-PP-2A MISCALIBRATED	P				1.00E-03
62	TOATL-1T	1		H	OPERATOR MISCALIBRATION LEAK DETECTOR TL-1	P				1.00E-03
63	TOATL-1U	1		H	OPERATOR FAILS TO RET TO NORM AFT MAINT TL-1 LEAK DETECTOR	P				1.00E-03
64	TOATL-3T	1		H	OPERATOR MISCALIBRATION OF LEAK DETECTOR TL-3	P				1.00E-03
65	TOATL-3U	1		H	OPERATOR FAILS TO RET TO NORM AFT MAINT TL-3	P				1.00E-03

..	C	FACTOR	U	DESC	TR	SO	LOCAT	S	PROB
562T	1		N	LDE-V562 MISCALIBRATED	P				1.00E-03
562U	1		N	LDE-V562 GROUNDING WIRE NOT ATTACHED TO SCREW	P				1.00E-03
P-AT	1		N	LDE-VP-SY-A MISCALIBRATED	P				1.00E-03
I277L	1	4	H	LEAK FROM INNER PIPE OF SN-277	P				4.80E-07
/562L	1	4	H	LEAK FROM INNER PIPE OF V562	P				4.80E-07
44S1_	1		N	PUMP P244-S-1 FAILS TO SHUTDOWN AS REQUIRED	P				7.00E-05
N277L	1	4	H	SN-277 PIPE ENCASEMENT LEAKS	P				4.80E-08
.V562L	1	4	H	V562 PIPE ENCASEMENT LEAKS	P				4.80E-08
.02A1I	1		N	RELAY LDI-PP-02A-1 CONTACTS FAIL TO TRANSFER	P				7.60E-05
1562AI	1		N	RELAY LDK-V562A CONTACTS FAIL TO TRANSFER	P				7.60E-05
AK-3-I	1		N	RELAY K-3 CONTACTS FAIL TO TRANSFER	P				7.60E-05
AM-3-I	1		N	RELAY M-3 CONTACTS FAIL TO TRANSFER	P				7.60E-05
APP-1I	1		N	RELAY LDI-PP-1 CONTACTS FAIL TO TRANSFER	P				7.60E-05
APP-2I	1		N	RELAY LDI-PP-2 CONTACTS FAIL TO TRANSFER	P				7.60E-05
IAPP2AI	1		N	RELAY LDI-PP-02A-1 CONTACTS FAIL TO TRANSFER	P				7.60E-05
IASYPPI	1		N	RELAY K-241-SY-PP CONTACTS FAIL TO TRANSFER	P				7.60E-05
RAV562I	1		N	RELAY LDK-V562 CONTACTS FAIL TO TRANSFER	P				7.60E-05
RAVP-AI	1		N	RELAY LDI-VP-SY-A CONTACTS FAIL TO TRANSFER	P				7.60E-05
SA244SL	1	4	H	P-244-S-1 PROCESS PUMP SEAL LEAKS	P				1.44E-04
VDA-1-L	1	4	H	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	P				1.44E-05
VDA-2-L	1	4	H	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	P				1.44E-05
TVDA-26L	1	4	H	241-SY-A VALVE PIT VALVE A-26 LEAKS EXTERNALLY	P				1.44E-05
TWA02A12	1	4	H	LEAK DETECTOR LDE-02A-1 WIRING FAILURE	P				1.44E-05
TWA08U12	1	4	H	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) LDE-08-U-151	P				1.44E-05
TWA08U22	1	4	H	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) FOR LDE-08-U-152 LEAK DETECTOR	P				1.44E-05
TWAL4562	1	4	H	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) LDE456	P				1.44E-05
TWALDEP2	1	2	H	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) LDE PP 24-TX	P				7.20E-06
TWAPP-22	1	4	H	LEAK DETECTOR LDE-PP-2 WIRING FAILURE	P				1.44E-05
TWAPP2A2	1	4	H	LEAK DETECTOR LDE-PP-2-A WIRING FAILURE	P				1.44E-05
TWATL-12	1	4	H	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) TL-1 LEAK DETECTOR	P				1.44E-05
TWATL-32	1	4	H	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) TL-3	P				1.44E-05
WAV5622	1	4	H	LEAK DETECTOR LDE-V562 WIRING FAILURE	P				1.44E-05
WAVP-A2	1	4	H	LEAK DETECTOR LDE-VP-SY-A WIRING FAILURE	P				1.44E-05

	TYPE	RATE	U	DESC	SOURCE	COMMON
1	AA P	2.3E-06	H	ALARM FAILS TO SOUND WHEN DEMANDED	HANFORD DATABASE	
2	CN L	1.0E-06	H	DIVERSION BOX CONNECTIONS LEAK	ENGR. JUDGEMENT HD	
3	EA M	1.0E-06	H	FLOW METER FAILS INDICATING HIGH OR NORMAL FLOW	HANFORD DATA BASE HD	
4	EA N	1E-06	H	FLOW ELEMENT FAILS LOW	HANFORD DATABASE	
5	EB L	1E-08	H	LEAK DETECTOR ELECTRODE PROBE BROKEN	HANFORD DATABASE-SAM	
6	EB O	2.7E-06	H	LEAK DETECTOR FAILS, NO OUTPUT SIGNAL	HANFORD DATABASE	
7	EB P	2E-05	H	LEAK DETECTOR PROBES CORRODED	HANFORD DATABASE-SAM	
8	EC N	2.5E-05	H	LEVEL ELEMENT FAILS LOW	HANFORD DATABASE	
9	EC O	2.5E-05	H	LEVEL ELEMENT FAILS, NO OUTPUT	HANFORD DATABASE	
10	FF L	1.9E-05	H	FITTINGS, CONNECTORS LEAK	EG&G TABLE 6	
11	HC L	4E-05	H	FLEX HOSE LEAKAGE	S2P-18	
12	IA N	1.4E-06	H	FLOW INDICATOR FAILS LOW, LOW INDICATION	HANFORD DATABASE	
13	IB O	1.4E-06	H	LEVEL INDICATOR FAILS, NO INDICATION	HANFORD DATABASE	
14	OA Q	1E-03	H	OPERATOR FAILS TO PERFORM A KNOWN TASK	HRA	
15	OA T	1E-03	H	OPERATOR MISCALIBRATION	HANFORD DATABASE	
16	OA U	1E-03	H	OPERATOR FAILS TO RET TO NORM AFT MAINT	HRA	
17	PA L	1E-08	H	PIPING LEAKS (PER FOOT OF < 3" PIPE)	HANFORD DATABASE	
18	PD L	3.0E-06	H	PUMP LEAKS	HANFORD DATABASE HD	
19	PD _	7E-05	H	ELECTRIC MOTOR DRIVEN PUMP FAILS TO STOP	SAME AS RELAY FAILS	
20	PE L	1E-09	H	PIPING LEAKS (PER FOOT OF > 3" PIPE)	HANFORD DATABASE	
21	PP L	1.0E-09	H	PIPE LEAKS	HANFORD DATA BASE HD	
22	RA I	7.6E-05	H	RELAY FAILS TO CHANGE STATE	HANFORD DATABASE	
23	RB P	2.5E-05	H	RECORDER FAILS	S2P-22	
24	SA L	3E-06	H	PUMP SEAL LEAKAGE	EG&G Table 2	
25	SC I	3.0E-5	H	THERMAL OVERLOAD SWITHCH FAILS TO OPEN	HANFORD DATA BASE HD	
26	SD I	3E-05	H	PUSHBUTTON CONTACTS FAIL TO TRANSFER	HANFORD DATABASE-HAN	
27	SI I	3E-05	H	PRESSURE SWITCH FAILS TO TRANSFER	HANFORD DATABASE	
28	TE P	3E-06	H	LEVEL TRANSMITTER FAILS TO TRANSMIT	HANFORD DATABASE	
29	VC L	1E-06	H	DIAPHRAGM VALVE EXTERNAL LEAKAGE	EG&G Table 2	
30	VD C	1.5E-07	H	MANUAL VALVE N.O. FTRO	HANFORD DATABASE	
31	VD L	3E-07	H	MANUAL VALVE EXTERNAL LEAKAGE	EG&G Table 2	
32	WA 2	3E-07	H	ELECTRICAL WIRE FAILS TO GROUND (SHORTS)	HANFORD DATABASE	

APPENDIX C

CUTSET FILE

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
1) P101					*1.19E-04
1) teb02a1o	LEAK DETECTOR ELEMENT LDE-02A-1 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	2.49E-05
THC-02AL	102-SY-02A PUMP PIT FLEX HOSE LEAKS	4E-05	48	1.92E-03	
2) TEBPP2AO	LEAK DETECTOR ELEMENT LDE-PP-2A MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.18E-05
TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	
3) TEBVP-AO	LEAK DETECTOR ELEMENT LDE-VP-SY-A MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.18E-05
TFFL-16L	241-SY-A VALVE PIT CONNECTOR L-16 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
4) TEB02A1O	LEAK DETECTOR ELEMENT LDE-02A-1 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.18E-05
TFFNOZGL	102-SY-02A PUMP PIT NOZZLE G LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
5) TEBPP-2O	LEAK DETECTOR ELEMENT LDE-PP-2 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.18E-05
TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	
6) TEB02A1O	LEAK DETECTOR ELEMENT LDE-02A-1 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.18E-05
TFFNOZAL	102-SY-02A PUMP PIT NOZZLE A LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
7) TEBVP-AO	LEAK DETECTOR ELEMENT LDE-VP-SY-A MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.18E-05
TFFL-15L	241-SY-A VALVE PIT CONNECTOR L-15 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
8) THC-02AL	102-SY-02A PUMP PIT FLEX HOSE LEAKS	4E-05	48	1.92E-03	1.92E-06
TOA02A1T	LDE-02A-1 MISCALIBRATED	1E-03	1	1.00E-03	
9) TEBPP2AO	LEAK DETECTOR ELEMENT LDE-PP-2A MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.87E-06
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
10) TEBPP-2O	LEAK DETECTOR ELEMENT LDE-PP-2 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.87E-06
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
11) TEB02A1P	LEAK DETECTOR LDE-02A-1 PROBES CORRODED	2E-05	48	9.60E-04	1.84E-06
THC-02AL	102-SY-02A PUMP PIT FLEX HOSE LEAKS	4E-05	48	1.92E-03	
12) TFFL-15L	241-SY-A VALVE PIT CONNECTOR L-15 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	9.12E-07
TOAVP-AT	LDE-VP-SY-A MISCALIBRATED	1E-03	1	1.00E-03	
13) TFFL-16L	241-SY-A VALVE PIT CONNECTOR L-16 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	9.12E-07
TOAVP-AT	LDE-VP-SY-A MISCALIBRATED	1E-03	1	1.00E-03	
14) TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	9.12E-07
TOAPP-2T	LDE-PP-2 MISCALIBRATED	1E-03	1	1.00E-03	
15) TFFNOZAL	102-SY-02A PUMP PIT NOZZLE A LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	9.12E-07
TOA02A1T	LDE-02A-1 MISCALIBRATED	1E-03	1	1.00E-03	
16) TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	9.12E-07
TOAPP2AT	LDE-PP-2A MISCALIBRATED	1E-03	1	1.00E-03	
17) TFFNOZGL	102-SY-02A PUMP PIT NOZZLE G LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	9.12E-07
TOA02A1T	LDE-02A-1 MISCALIBRATED	1E-03	1	1.00E-03	
18) TEBPP2AP	LEAK DETECTOR LDE-PP-2A PROBES CORRODED	2E-05	48	9.60E-04	8.76E-07
TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	
19) TEB02A1P	LEAK DETECTOR LDE-02A-1 PROBES CORRODED	2E-05	48	9.60E-04	8.76E-07
TFFNOZAL	102-SY-02A PUMP PIT NOZZLE A LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
20) TEBVP-AP	LEAK DETECTOR LDE-VP-SY-A PROBES CORRODED	2E-05	48	9.60E-04	8.76E-07
TFFL-15L	241-SY-A VALVE PIT CONNECTOR L-15 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
21) TEBPP-2P	LEAK DETECTOR LDE-PP-2 PROBES CORRODED	2E-05	48	9.60E-04	8.76E-07
TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	
22) TEBVP-AP	LEAK DETECTOR LDE-VP-SY-A PROBES CORRODED	2E-05	48	9.60E-04	8.76E-07
TFFL-16L	241-SY-A VALVE PIT CONNECTOR L-16 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
23) TEB02A1P	LEAK DETECTOR LDE-02A-1 PROBES CORRODED	2E-05	48	9.60E-04	8.76E-07
TFFNOZGL	102-SY-02A PUMP PIT NOZZLE G LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
24) TEBPP2AO	LEAK DETECTOR ELEMENT LDE-PP-2A MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.87E-07
TVOA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
25) TEBPP-2O	LEAK DETECTOR ELEMENT LDE-PP-2 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.87E-07
TVOA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
26) PVOA-30L	MANUAL VALVE A-3 LEAKS	3E-07	48	1.44E-05	1.87E-07
TEBPP-2O	LEAK DETECTOR ELEMENT LDE-PP-2 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	
27) TEBVP-AO	LEAK DETECTOR ELEMENT LDE-VP-SY-A MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.87E-07
TVOA-26L	241-SY-A VALVE PIT VALVE A-26 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
28) TEBPP-2O	LEAK DETECTOR ELEMENT LDE-PP-2 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.87E-07
TVOA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
29) PVOA-20L	MANUAL VALVE A-2 LEAKS	3E-07	48	1.44E-05	1.87E-07
TEBPP-2O	LEAK DETECTOR ELEMENT LDE-PP-2 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	
30) PVOA-10L	MANUAL VALVE A-1 LEAKS	3E-07	48	1.44E-05	1.87E-07
TEBPP-2O	LEAK DETECTOR ELEMENT LDE-PP-2 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	
31) TEBPP2AO	LEAK DETECTOR ELEMENT LDE-PP-2A MECHANICAL FAILURE	2.7E-04	48	1.30E-02	1.87E-07
TVOA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
32) THC-02AL	102-SY-02A PUMP PIT FLEX HOSE LEAKS	4E-05	48	1.92E-03	1.46E-07

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
TRASYPPI	RELAY K-241-SY-PP CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
33) THC-02AL	102-SY-02A PUMP PIT FLEX HOSE LEAKS	4E-05	48	1.92E-03	1.46E-07
TRA02A1I	RELAY LDI-PP-02A-1 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
34) PPOPM-1L	LEAK OCCURS IN PUMP P-1 IN 244-TX PUMP PIT	3.0E-06	48	1.44E-04	1.44E-07
TOALDEPU	OPERATOR FAILS TO RET TO NORM AFT MAINT LDE PP IN 244TX PMP PIT	1E-03	1	1.00E-03	
35) TOAPP-2T	LDE-PP-2 MISCALIBRATED	1E-03	1	1.00E-03	1.44E-07
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
36) TOAPP2AT	LDE-PP-2A MISCALIBRATED	1E-03	1	1.00E-03	1.44E-07
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
37) PPOPM-1L	LEAK OCCURS IN PUMP P-1 IN 244-TX PUMP PIT	3.0E-06	48	1.44E-04	1.44E-07
TOALDEPT	OPERATOR MISCALIBRATION OF LDE PP IN 244TX PUMP PIT	1E-03	1	1.00E-03	
38) PPOPM-1L	LEAK OCCURS IN PUMP P-1 IN 244-TX PUMP PIT	3.0E-06	48	1.44E-04	1.38E-07
TEBLDEPP	LEAK DETECTOR PROBES CORRODED 244TX PUMP PIT	2E-05	48	9.60E-04	
39) TEBPP-2P	LEAK DETECTOR LDE-PP-2 PROBES CORRODED	2E-05	48	9.60E-04	1.38E-07
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
40) TEBPP2AP	LEAK DETECTOR LDE-PP-2A PROBES CORRODED	2E-05	48	9.60E-04	1.38E-07
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
41) TFFNOZGL	102-SY-02A PUMP PIT NOZZLE G LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	6.93E-08
TRASYPPI	RELAY K-241-SY-PP CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
42) TFFL-15L	241-SY-A VALVE PIT CONNECTOR L-15 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	6.93E-08
TRASYPPI	RELAY K-241-SY-PP CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
43) TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	6.93E-08
TRAK-3-I	RELAY K-3 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
44) TFFL-16L	241-SY-A VALVE PIT CONNECTOR L-16 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	6.93E-08
TRAVP-AI	RELAY LDI-VP-SY-A CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
45) TFFL-16L	241-SY-A VALVE PIT CONNECTOR L-16 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	6.93E-08
TRASYPPI	RELAY K-241-SY-PP CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
46) TFFL-15L	241-SY-A VALVE PIT CONNECTOR L-15 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	6.93E-08
TRAVP-AI	RELAY LDI-VP-SY-A CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
47) TFFNOZAL	102-SY-02A PUMP PIT NOZZLE A LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	6.93E-08
TRASYPPI	RELAY K-241-SY-PP CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
48) TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	6.93E-08
TRAPP-1I	RELAY LDI-PP-1 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
49) TFFNOZAL	102-SY-02A PUMP PIT NOZZLE A LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	6.93E-08
TRA02A1I	RELAY LDI-PP-02A-1 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
50) TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	6.93E-08
TRAM-3-I	RELAY M-3 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
51) TFFNOZGL	102-SY-02A PUMP PIT NOZZLE G LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	6.93E-08
TRA02A1I	RELAY LDI-PP-02A-1 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	
52) TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	6.38E-08
TP04481	PUMP P244-S-1 FAILS TO SHUTDOWN AS REQUIRED	7E-05	1	7.00E-05	
53) PVCDOV1L	AIR OPERATED VALVE DOV-1 LEAKS	1E-06	48	4.80E-05	4.80E-08
TOALDEPT	OPERATOR MISCALIBRATION OF LDE PP IN 244TX PUMP PIT	1E-03	1	1.00E-03	
54) PCNU8U9L	LEAK OCCURS IN 241-TX-152 CONNECTION U-8 AND U-9	1.0E-06	48	4.80E-05	4.80E-08
TOALDEPU	OPERATOR FAILS TO RET TO NORM AFT MAINT LDE PP IN 244TX PMP PIT	1E-03	1	1.00E-03	
55) PVCDOV1L	AIR OPERATED VALVE DOV-1 LEAKS	1E-06	48	4.80E-05	4.80E-08
TOALDEPU	OPERATOR FAILS TO RET TO NORM AFT MAINT LDE PP IN 244TX PMP PIT	1E-03	1	1.00E-03	
56) PCNL7L3L	LEAK OCCURS IN 241-U-151 CONNECTION L-7 AND L-3	1.0E-06	48	4.80E-05	4.80E-08
TOAD8U1U	OPERATOR FAILS TO RET TO NORM AFT MAINT LDE-08-U-151	1E-03	1	1.00E-03	
57) PCNL7L3L	LEAK OCCURS IN 241-U-151 CONNECTION L-7 AND L-3	1.0E-06	48	4.80E-05	4.80E-08
TOAD8U1T	OPERATOR MISCALIBRATION OF LDE-08-U-151	1E-03	1	1.00E-03	
58) PCNU9U2L	LEAK OCCURS IN 241-U-152 CONNECTION U-9 AND U-2	1.0E-06	48	4.80E-05	4.80E-08
TOAD8U2T	OPERATOR MISCALIBRATION OF LDE-08-U-152 LEAK DETECTOR	1E-03	1	1.00E-03	
59) PCNU8U9L	LEAK OCCURS IN 241-TX-152 CONNECTION U-8 AND U-9	1.0E-06	48	4.80E-05	4.80E-08
TOALDEPT	OPERATOR MISCALIBRATION OF LDE PP IN 244TX PUMP PIT	1E-03	1	1.00E-03	
60) PCNU9U2L	LEAK OCCURS IN 241-U-152 CONNECTION U-9 AND U-2	1.0E-06	48	4.80E-05	4.80E-08
TOAD8U2U	OPERATOR FAILS TO RET TO NORM AFT MAINT LDE-08-U-152 LEAK DETECTOR	1E-03	1	1.00E-03	
61) PPPV452L	LEAK OCCURS IN PIPING FROM 241-U-152 TO 241-U-151	1.0E-09	48	4.80E-08	4.80E-08
62) PPPV422L	LEAK OCCURS IN V-422 PIPING FROM 241-U-152 TO 241-U-151	1.0E-09	48	4.80E-08	4.80E-08
63) PCNU8U9L	LEAK OCCURS IN 241-TX-152 CONNECTION U-8 AND U-9	1.0E-06	48	4.80E-05	4.61E-08
TEBLDEPP	LEAK DETECTOR PROBES CORRODED 244TX PUMP PIT	2E-05	48	9.60E-04	
64) PVCDOV1L	AIR OPERATED VALVE DOV-1 LEAKS	1E-06	48	4.80E-05	4.61E-08
TEBLDEPP	LEAK DETECTOR PROBES CORRODED 244TX PUMP PIT	2E-05	48	9.60E-04	
65) PCNL7L3L	LEAK OCCURS IN 241-U-151 CONNECTION L-7 AND L-3	1.0E-06	48	4.80E-05	4.61E-08

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ODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	S.S. PROB.	MOD./CS. PROB.
TEBD8U1P	LEAK DETECTOR PROBES CORRODED LDE-D8-U-151	2E-05	48	9.60E-04	
66) PCNU9U2L	LEAK OCCURS IN 241-U-152 CONNECTION U-9 AND U-2	1.0E-06	48	4.80E-05	4.61E-08
TEBD8U2P	LEAK DETECTOR PROBES CORRODED LDE-D8-U-152 CATCH TANK	2E-05	48	9.60E-04	
67) THC-02AL	102-SY-02A PUMP PIT FLEX HOSE LEAKS	4E-05	48	1.92E-03	2.76E-08
TWA02A12	LEAK DETECTOR LDE-02A-1 WIRING FAILURE	3E-07	48	1.44E-05	
68) PVDHV-2L	MANUAL VALVE HV-2 LEAKS	3E-07	48	1.44E-05	1.44E-08
TOALDEPU	OPERATOR FAILS TO RET TO NORM AFT MAINT LDE PP IN 244TX PMP PIT	1E-03	1	1.00E-03	
69) TOAPP2AT	LDE-PP-2A MISCALIBRATED	1E-03	1	1.00E-03	1.44E-08
TVDA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
70) PVDA-30L	MANUAL VALVE A-3 LEAKS	3E-07	48	1.44E-05	1.44E-08
TOAPP-2T	LDE-PP-2 MISCALIBRATED	1E-03	1	1.00E-03	
71) PVDA-20L	MANUAL VALVE A-2 LEAKS	3E-07	48	1.44E-05	1.44E-08
TOAPP-2T	LDE-PP-2 MISCALIBRATED	1E-03	1	1.00E-03	
72) PVDA-10L	MANUAL VALVE A-1 LEAKS	3E-07	48	1.44E-05	1.44E-08
TOAPP-2T	LDE-PP-2 MISCALIBRATED	1E-03	1	1.00E-03	
73) TOAPP-2T	LDE-PP-2 MISCALIBRATED	1E-03	1	1.00E-03	1.44E-08
TVDA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
74) TOAPP-2T	LDE-PP-2 MISCALIBRATED	1E-03	1	1.00E-03	1.44E-08
TVDA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
75) TOAVP-AT	LDE-VP-SY-A MISCALIBRATED	1E-03	1	1.00E-03	1.44E-08
TVDA-26L	241-SY-A VALVE PIT VALVE A-26 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
76) TOAPP2AT	LDE-PP-2A MISCALIBRATED	1E-03	1	1.00E-03	1.44E-08
TVDA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
77) PVDHV-2L	MANUAL VALVE HV-2 LEAKS	3E-07	48	1.44E-05	1.44E-08
TOALDEPT	OPERATOR MISCALIBRATION OF LDE PP IN 244TX PUMP PIT	1E-03	1	1.00E-03	
78) PVDA-10L	MANUAL VALVE A-1 LEAKS	3E-07	48	1.44E-05	1.38E-08
TESPP-2P	LEAK DETECTOR LDE-PP-2 PROBES CORRODED	2E-05	48	9.60E-04	
79) TESPP-2P	LEAK DETECTOR LDE-PP-2 PROBES CORRODED	2E-05	48	9.60E-04	1.38E-08
TVDA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
80) PVDHV-2L	MANUAL VALVE HV-2 LEAKS	3E-07	48	1.44E-05	1.38E-08
TESLDEPP	LEAK DETECTOR PROBES CORRODED 244TX PUMP PIT	2E-05	48	9.60E-04	
81) TESPP-2P	LEAK DETECTOR LDE-PP-2 PROBES CORRODED	2E-05	48	9.60E-04	1.38E-08
TVDA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
82) TESVP-AP	LEAK DETECTOR LDE-VP-SY-A PROBES CORRODED	2E-05	48	9.60E-04	1.38E-08
TVDA-26L	241-SY-A VALVE PIT VALVE A-26 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
83) TESPP2AP	LEAK DETECTOR LDE-PP-2A PROBES CORRODED	2E-05	48	9.60E-04	1.38E-08
TVDA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
84) TESPP2AP	LEAK DETECTOR LDE-PP-2A PROBES CORRODED	2E-05	48	9.60E-04	1.38E-08
TVDA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
85) PVDA-30L	MANUAL VALVE A-3 LEAKS	3E-07	48	1.44E-05	1.38E-08
TESPP-2P	LEAK DETECTOR LDE-PP-2 PROBES CORRODED	2E-05	48	9.60E-04	
86) PVDA-20L	MANUAL VALVE A-2 LEAKS	3E-07	48	1.44E-05	1.38E-08
TESPP-2P	LEAK DETECTOR LDE-PP-2 PROBES CORRODED	2E-05	48	9.60E-04	
87) TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	1.31E-08
TWAPP-22	LEAK DETECTOR LDE-PP-2 WIRING FAILURE	3E-07	48	1.44E-05	
88) TFFNOZGL	102-SY-02A PUMP PIT NOZZLE G LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	1.31E-08
TWA02A12	LEAK DETECTOR LDE-02A-1 WIRING FAILURE	3E-07	48	1.44E-05	
89) TFFL-15L	241-SY-A VALVE PIT CONNECTOR L-15 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	1.31E-08
TWAVP-A2	LEAK DETECTOR LDE-VP-SY-A WIRING FAILURE	3E-07	48	1.44E-05	
90) TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	1.31E-08
TWAPP2A2	LEAK DETECTOR LDE-PP-2-A WIRING FAILURE	3E-07	48	1.44E-05	
91) TFFL-16L	241-SY-A VALVE PIT CONNECTOR L-16 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	1.31E-08
TWAVP-A2	LEAK DETECTOR LDE-VP-SY-A WIRING FAILURE	3E-07	48	1.44E-05	
92) TFFNOZAL	102-SY-02A PUMP PIT NOZZLE A LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	1.31E-08
TWA02A12	LEAK DETECTOR LDE-02A-1 WIRING FAILURE	3E-07	48	1.44E-05	
93) TRAM-3-I	RELAY M-3 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-08
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
94) TRAK-3-1	RELAY K-3 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-08
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
95) TRAPP-1I	RELAY LDI-PP-1 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-08
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
96) TP044S1_	PUMP P244-S-1 FAILS TO SHUTDOWN AS REQUIRED	7E-05	1	7.00E-05	1.01E-08
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
97) TEB02A10	LEAK DETECTOR ELEMENT LDE-02A-1 MECHANICAL FAILURE	2.7E-04	48	1.30E-02	6.22E-09

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
TPAN277L	LEAK FROM INNER PIPE OF SN-277	1E-08	48	4.80E-07	
98) TAA22G1P	ANNUNCIATOR 22G1 FAILS TO ALARM	2.3E-06	1	2.30E-06	4.42E-09
THC-02AL	102-SY-02A PUMP PIT FLEX HOSE LEAKS	4E-05	48	1.92E-03	
99) TAAG267P	ANNUNCIATOR 67-G2 FAILS TO ALARM	2.3E-06	1	2.30E-06	2.10E-09
TFFCON3L	244-S CATCH TANK CONNECTOR 3 LEAKS	1.9E-05	48	9.12E-04	
100) TAA22G1P	ANNUNCIATOR 22G1 FAILS TO ALARM	2.3E-06	1	2.30E-06	2.10E-09
TFFNOZGL	102-SY-02A PUMP PIT NOZZLE G LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
101) TAA22G1P	ANNUNCIATOR 22G1 FAILS TO ALARM	2.3E-06	1	2.30E-06	2.10E-09
TFFNOZAL	102-SY-02A PUMP PIT NOZZLE A LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
102) TAA22G1P	ANNUNCIATOR 22G1 FAILS TO ALARM	2.3E-06	1	2.30E-06	2.10E-09
TFFL-16L	241-SY-A VALVE PIT CONNECTOR L-16 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
103) TAA22G1P	ANNUNCIATOR 22G1 FAILS TO ALARM	2.3E-06	1	2.30E-06	2.10E-09
TFFL-15L	241-SY-A VALVE PIT CONNECTOR L-15 LEAKS EXTERNALLY	1.9E-05	48	9.12E-04	
104) TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	2.07E-09
TWAPP-22	LEAK DETECTOR LDE-PP-2 WIRING FAILURE	3E-07	48	1.44E-05	
105) TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	2.07E-09
TWAPP2A2	LEAK DETECTOR LDE-PP-2-A WIRING FAILURE	3E-07	48	1.44E-05	
106) TRAPP-1I	RELAY LDI-PP-1 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-09
TVDA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
107) TRASYPPI	RELAY K-241-SY-PP CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-09
TVDA-26L	241-SY-A VALVE PIT VALVE A-26 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
108) TRAM-3-I	RELAY M-3 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-09
TVDA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
109) TRAM-3-I	RELAY M-3 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-09
TVDA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
110) TRAK-3-I	RELAY K-3 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-09
TVDA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
111) TRAK-3-I	RELAY K-3 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-09
TVDA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
112) TRAVP-AI	RELAY LDI-VP-SY-A CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-09
TVDA-26L	241-SY-A VALVE PIT VALVE A-26 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
113) TRAPP-1I	RELAY LDI-PP-1 CONTACTS FAIL TO TRANSFER	7.6E-05	1	7.60E-05	1.09E-09
TVDA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
114) PPOPM-1L	LEAK OCCURS IN PUMP P-1 IN 244-TX PUMP PIT	3.0E-06	48	1.44E-04	1.04E-09
TWALDEP2	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) LDE PP 244TX	3E-07	24	7.20E-06	
115) TP044S1_	PUMP P244-S-1 FAILS TO SHUTDOWN AS REQUIRED	7E-05	1	7.00E-05	1.01E-09
TVDA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
116) TP044S1_	PUMP P244-S-1 FAILS TO SHUTDOWN AS REQUIRED	7E-05	1	7.00E-05	1.01E-09
TVDA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	
117) PCNU9U2L	LEAK OCCURS IN 241-U-152 CONNECTION U-9 AND U-2	1.0E-06	48	4.80E-05	6.91E-10
TWADBU22	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) FOR LDE-DB-U-152 LEAK DETECTO	3E-07	48	1.44E-05	
118) PCNL7L3L	LEAK OCCURS IN 241-U-151 CONNECTION L-7 AND L-3	1.0E-06	48	4.80E-05	6.91E-10
TWADBU12	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) LDE-DB-U-151	3E-07	48	1.44E-05	
119) TOA02A1T	LDE-02A-1 MISCALIBRATED	1E-03	1	1.00E-03	4.80E-10
TPAN277L	LEAK FROM INNER PIPE OF SN-277	1E-08	48	4.80E-07	
120) TOAV562U	LDE-V562 GROUNDING WIRE NOT ATTACHED TO SCREW	1E-03	1	1.00E-03	4.80E-10
TPAV562L	LEAK FROM INNER PIPE OF V562	1E-08	48	4.80E-07	
121) TOAV562T	LDE-V562 MISCALIBRATED	1E-03	1	1.00E-03	4.80E-10
TPAV562L	LEAK FROM INNER PIPE OF V562	1E-08	48	4.80E-07	
122) TEB02A1P	LEAK DETECTOR LDE-02A-1 PROBES CORRODED	2E-05	48	9.60E-04	4.61E-10
TPAN277L	LEAK FROM INNER PIPE OF SN-277	1E-08	48	4.80E-07	
123) TEBV562P	LEAK DETECTOR PROBE V562 CORRODED	2E-05	48	9.60E-04	4.61E-10
TPAV562L	LEAK FROM INNER PIPE OF V562	1E-08	48	4.80E-07	
124) PCNU8U9L	LEAK OCCURS IN 241-TX-152 CONNECTION U-8 AND U-9	1.0E-06	48	4.80E-05	3.46E-10
TWALDEP2	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) LDE PP 244TX	3E-07	24	7.20E-06	
125) PVCDOV1L	AIR OPERATED VALVE DOV-1 LEAKS	1E-06	48	4.80E-05	3.46E-10
TWALDEP2	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) LDE PP 244TX	3E-07	24	7.20E-06	
126) TAAG267P	ANNUNCIATOR 67-G2 FAILS TO ALARM	2.3E-06	1	2.30E-06	3.31E-10
TSA244SL	P-244-S-1 PROCESS PUMP SEAL LEAKS	3E-06	48	1.44E-04	
127) TVDA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	2.07E-10
TWAPP2A2	LEAK DETECTOR LDE-PP-2-A WIRING FAILURE	3E-07	48	1.44E-05	
128) PVDA-30L	MANUAL VALVE A-3 LEAKS	3E-07	48	1.44E-05	2.07E-10
TWAPP-22	LEAK DETECTOR LDE-PP-2 WIRING FAILURE	3E-07	48	1.44E-05	
129) PVDA-20L	MANUAL VALVE A-2 LEAKS	3E-07	48	1.44E-05	2.07E-10

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MODULE/EVENT NAME	DESCRIPTION	RATE	EXPOSURE	B.E. PROB.	MOD./CS. PROB.
TWAPP-22	LEAK DETECTOR LDE-PP-2 WIRING FAILURE	3E-07	48	1.44E-05	
130) PVDA-10L	MANUAL VALVE A-1 LEAKS	3E-07	48	1.44E-05	2.07E-10
TWAPP-22	LEAK DETECTOR LDE-PP-2 WIRING FAILURE	3E-07	48	1.44E-05	
131) TVDA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	2.07E-10
TWAPP-22	LEAK DETECTOR LDE-PP-2 WIRING FAILURE	3E-07	48	1.44E-05	
132) TVDA-2-L	102-SY-02A PUMP PIT VALVE A-2 LEAKS EXTERNALLY	3E-07	48	1.44E-05	2.07E-10
TWAPP-22	LEAK DETECTOR LDE-PP-2 WIRING FAILURE	3E-07	48	1.44E-05	
133) TVDA-26L	241-SY-A VALVE PIT VALVE A-26 LEAKS EXTERNALLY	3E-07	48	1.44E-05	2.07E-10
TWAVP-A2	LEAK DETECTOR LDE-VP-SY-A WIRING FAILURE	3E-07	48	1.44E-05	
134) TVDA-1-L	102-SY-02A PUMP PIT VALVE A-1 LEAKS EXTERNALLY	3E-07	48	1.44E-05	2.07E-10
TWAPP2A2	LEAK DETECTOR LDE-PP-2-A WIRING FAILURE	3E-07	48	1.44E-05	
135) PVDHV-2L	MANUAL VALVE HV-2 LEAKS	3E-07	48	1.44E-05	1.04E-10
TWALDEP2	ELECTRICAL WIRE FAILS TO GROUND (SHORTS) LDE PP 244TX	3E-07	24	7.20E-06	

APPENDIX B

ANALYSIS OF EXPECTED TEMPERATURE RESPONSE IN TANK T-101 FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

Westinghouse Hanford Company **Internal Memo**

From: Waste Tank Safety Analysis 29120-MK-92156
Phone: 6-2520 H5-32
Date: November 11, 1992
Subject: ANALYSIS OF EXPECTED TEMPERATURE RESPONSE IN TANK T-101 FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

To: N. J. Milliken H5-32

cc: J. M. Grigsby H5-32
R. D. Crowe H5-32
MK File/LB

Attached is a report of the subject analysis.

Maryanne Kummerer

M. Kummerer
Senior Engineer

cab

Attachment

EXPECTED WASTE TEMPERATURE RISE FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

Summary and Conclusions

Calculations were performed to estimate the maximum rate of temperature rise in the waste contents of Tank T-101 should cooling to the submersible pump motor be lost. For simplicity of calculation, it was assumed that heat from the pump was transported only in the radial direction, through the saltwell and into the waste. The effects of heat loss from the system in the upward direction were neglected.

The waste was assumed to be ferrocyanide sludge. The minimum waste temperature of concern was taken to be about 200 °C. The heat generation rate from the uncooled motor was taken to be 2000 watts. The calculated time for the temperature in the waste to reach 200 °C was about 1.5 days.

To reach this result required that the pump motor achieve unrealistically high temperatures (about 950 °C). Damage to the motor would prevent power being supplied to it well before this temperature is reached. Heat leaving the system by upward flow of heated air through the saltwell, and by conduction from the waste surface into the tank vapor space, would further mitigate the temperature rise. Therefore, it is concluded that, if the pump were to continue running for a time without cooling flow, an increase of the temperatures in the tank contents to a hazardous level is not expected.

Method of Calculation

The assumed geometry was a series of three concentric cylinders with the inner cylinder representing the pump, the middle cylinder representing the air gap between the pump and the saltwell wall, and the outer cylinder representing the tank contents. The heat output of the pump was estimated to be 2000 watts. This value was based on the specified minimum flow (0.25 ft/s) required to cool the pump during normal operations. Test information needed to calculate the pump heat was obtained from the vendor of the motor (Franklin Electric). The pump heat was calculated using the equation for surface convection:

$$q = hA(T_m - T_f)$$

Where:
- q = heat generation rate (watts)
- h = the heat transfer coefficient (W/m^2 °C)
- A = the wetted surface of the motor (0.19 m^2)
- T_m = test temperature of the motor shell (38°C)
- T_f = temperature of the test fluid (water at 19°C)

EXPECTED WASTE TEMPERATURE RISE FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

The heat transfer coefficient, h, was calculated using the relation for turbulent flow of water in annular spaces given in Marks, 1951:

$$h=160(1+0.012t_f)\frac{V^{0.8}}{D^{0.2}}$$

Where: t_f = fluid temperature (65.6 °F)
V = fluid linear velocity (0.25 ft/s)
D = annular clearance in inches between the motor and shroud (1 inch)

This gave a value for h of about 94 BTU/hr ft^2 °F (535 W/m^2 °C). Using this value in the convection equation yields a waste heat value for the motor of 1930 watts. This was rounded to 2000 watts for the purpose of the calculations.

Solution for the transient temperatures at radial distances from the pump were calculated using the TRUMP (Edwards, 1972) computer code. The code uses a finite difference method to solve the heat balance equation for a variety of geometries. A one dimensional, cylindrical geometry was used for this case. This is analogous to modeling the case as an infinitely long cylinder with heat flow in the radial direction only. The dimensions and physical parameters used in the model are discussed below:

Heat Source - The heat source of 2000 watts was distributed over the volume of the inner cylinder, with a radius of 2 inches (.05 m) and a 1 meter length. This gave a volumetric heat source of 2.5 x 10^5 W/m^3.

Radial Dimensions - The pump was modeled as steel with a radius of .05 m. The saltwell space, with a radius of .1 m, was given the properties of air. The remainder of the model, to the outer tank radius of 11.4 m, was sludge. The thickness of the steel shroud and the saltwell were interposed between the pump and saltwell space, and the saltwell space and waste, respectively. Interface nodes were used between materials to model the resistance to heat flow expected where materials with diverse thermal conductivities are adjacent to each other.

EXPECTED WASTE TEMPERATURE RISE FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

Thermal Properties - The thermal properties used for the three materials are given in the following table.

Material	Density kg/m^3	Heat Capacity J/kg °C	Thermal Conductivity W/m °C
Steel	8000	500	50
Air	1.3	1006	.18*
Sludge**	1500	3000	2.0

* The thermal conductivity of air at about 300 K is given as .03 W/m °C. This value was multiplied by 6 to simulate the combined effect of conduction and convection through the air gap.

** The density and heat capacity of the sludge are those given in Grigsby, 1992. The thermal conductivity is that obtained from testing of ferrocyanide waste simulants as reported in Meeuwsen, 1992.

Initial and Boundary Conditions - The starting temperature for the whole system was taken to be 68 °F (20.3 °C). This is the maximum temperature for tank 101-T given in Hanlon, May 1992. A constant temperature of 20.3 °C was imposed at the tank outer boundary.

Discussion

The calculated time for the temperatures in the waste near the saltwell to reach 200 °C was about 1.5 days. This is on the order of the time it would take to heat the one foot thickness of sludge adjacent to the saltwell to 200 °C adiabatically with 2000 watts heat input. Therefore, it is considered reasonable.

The simplified treatment for modeling purposes neglected important pathways by which heat would leave the system in the real case. As the temperature of the air in the saltwell rises, the density of the air will decrease. The warmer air will flow upward carrying heat out of the system. Additionally, as the temperature of the sludge rises, some of its heat will be lost by conduction to the vapor space above it. These heat loss mechanisms, if accounted for, would increase the time required to reach sludge temperatures of concern.

EXPECTED WASTE TEMPERATURE RISE FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

References

Edwards, A. L., 1972, "TRUMP: A Computer Program for Transient and Steady-State Temperature Distributions in Multidimensional Systems", UCRL-14754, Rev. 3, Lawrence Livermore Laboratory, Livermore, CA.

Franklin Electric, 1988, "Submersible Motors: Application, Installation, Maintenance Manual", Franklin Electric, Bluffton, IN.

Grigsby, J. M., et al, 1992, "Ferrocyanide Waste Tank Hazard Assessment - Interim Report", WHC-SD-WM-RPT-032, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Hanlon, B. M., 1992, "Tank Farm Surveillance and Waste Status Summary Report for May, 1992", WHC-EP_0182-50, Westinghouse Hanford Company, Richland, WA.

Marks, L. S., 1951, Mechanical Engineers' Handbook, Fifth Edition, McGraw-Hill Book Company, Inc., New York.

Meeuwsen, P. V., 1992, "Test Report for Thermal Conductivity of Ferrocyanide Waste Simulants," WHC-SD-WM-TRP-079, Westinghouse Hanford Company, Richland, Washington.

Section 4.4

Safety Evaluation and Request for Authorization to Use Submersible Pump

Westinghouse
Hanford Company

P.O. Box 1970
Richland, WA 99352

Thomas M Anderson
President

December 15, 1992

9258546

Mr. John D. Wagoner, Manager
U.S. Department of Energy
Richland Field Office
Richland, Washington 99352

Dear Mr. Wagoner:

SUBMITTAL OF SAFETY EVALUATION FOR EMERGENCY PUMPING OF TANK 241-T-101 AND REQUEST FOR AUTHORIZATION TO USE A SUBMERSIBLE PUMP

References:

(1) Letter, R. F. Christensen, RL, to President, WHC, "Transmittal of Comments on Amended Criticality Safety Justification for Continued Operation to Support Stabilization Activities in Certain SSTs," SFD:RFC, dated November 30, 1992.

(2) Letter, R. F. Christensen, RL, to President, WHC, "Safety Assessment and Environmental Assessment for Interim Stabilization of Ferrocyanide Tanks," SFD:WFH, dated November 25, 1992.

(3) Letter, H. D. Harmon, WHC, to J. H. Anttonen, RL, "Tank 241-T-101 Corrective Actions, Recommendations and Requests," 92076488 R3, dated November 25, 1992.

(4) Letter, H. D. Harmon, WHC, to J. H. Anttonen, RL, "Tank 241-T-101 Corrective Actions, Recommendations and Requests," 92076488 R1, dated October 30, 1992.

(5) Letter, M. A. Payne, WHC, to R. E. Gerton, RL, "Transmittal of the Amended Justification for Continued Operations to Support Stabilization Activities in 102-BY, 109-BY, 102-C, 107-C, 110-C and 101-T," 9257718, dated October 21, 1992.

(6) Letter, D. C. Richardson, WHC, to R. E. Gerton, RL, "Completion of Milestone 2024: Complete Safety Assessment for Pumping Ferrocyanide Tanks; and Milestone 2001: Submit Recommendations on Interim Stabilization of Ferrocyanide Tanks in Support of the TPA," 9257308, dated September 30, 1992.

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The Westinghouse Hanford Company (WHC) has submitted the following documents to the U.S. Department of Energy, Richland Field Office (RL):

- The safety assessment (SA) and the environmental assessment (EA) for interim stabilization (References 3 and 6) of ferrocyanide tanks (including Tank 241-T-101).

- An amended Justification for Continued Operations (JCO) and supporting Criticality Safety Evaluation Report (CSER) for the criticality Unreviewed Safety Question in support of interim stabilization of six Single-Shell Tanks (SSTs) including Tank 241-T-101 (Reference 5).

WHC has requested RL concurrence (Reference 4) to interim stabilize Tank 241-T-101, which is on the list of ferrocyanide-containing tanks. WHC has submitted the revised EA and Finding of No Significant Impact (FONSI) of pumping Tank 241-T-101 in response to Reference 2, and has requested RL approval (Reference 3) to interim stabilize Tank 241-T-101, based on the SA, EA, FONSI, and amended JCO that have been transmitted.

The purpose of this letter is to:

- Partially respond to Reference 1.

- Respond to Reference 2.

- Submit a safety evaluation (SE) which is specific to the emergency pumping (emergency interim stabilization) of Tank 241-T-101 only.

- Repeat the request for authorization to emergency pump Tank 241-T-101.

Discussion of these four items is as follows:

Partial Response to Reference 1

WHC has reviewed Reference 1 which includes comments on the amended JCO and CSER (Reference 5). In response to Reference 1, WHC will submit a revised JCO by December 18, 1992.

One of the comments in Reference 1 pertained to the potential that ferrocyanide might be transferred to Tank 241-SY-102 with the pumped liquids from 241-T-101. The basis for this concern is that experiments at Pacific Northwest Laboratory (PNL-8387: *Ferrocyanide*

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Safety Project Subtask 3.4 - Aging Studies Fiscal Year 1992 Annual Report) have shown that sodium nickel ferrocyanide dissociates in higher pH (greater than pH = 12) aqueous solutions, allowing the ferrocyanide ion [$Fe(CN)_6^{-4}$] to enter solution and nickel to precipitate as insoluble $Ni(OH)_2$. Therefore, the nickel is unavailable for precipitation of ferrocyanide if the pH is lowered again to 10 or less.

Research done by PNL and WHC indicates that this phenomenon does not present a significant hazard for ferrocyanide reactivity in Tank 241-SY-102 for the following reasons:

1) Based upon historical records, Tank 241-T-101 does not contain significant quantities of ferrocyanide. Report WHC-SD-WM-ER-133, Rev. 0, *Ferrocyanide Tank Inventories*, by G. L. Borsheim and B. C. Simpson, shows a ferrocyanide inventory for this tank of less than 1,000 gram-moles.

2) The available moisture in the receiver tank will be much too great to allow any ferrocyanide transferred to be reactive. The hydroxide content in 241-SY-102 is in excess of a pH of 13, which is the condition under which ferrocyanide is expected to dissociate under radiolysis--eventually going to iron hydroxide, carbon dioxide, and ammonia.

3) Chemical analyses of liquid samples from other ferrocyanide tanks show total cyanide concentrations, reported as CN^-, of less than 50 parts per million (ppm), even when the pH was above 13. This corresponds to a ferrocyanide [$Fe(CN)_6^{-4}$] concentration of about 70 ppm. If the 30,000 gallons of liquid pumped from Tank 241-T-101 were to contain ferrocyanide at 70 ppm, the amount transferred would be about 50 gram-moles. The 50 gram-moles would be small compared to the 1000 gram-moles required for a tank to be put on the list for ferrocyanide content.

Based upon the above discussion and a review of the comments in Reference 1, WHC has reconfirmed the conclusion that pumping of Tank 241-T-101 can be carried out without undue risk to onsite workers or the general public.

Response to Reference 2

Reference 2 transmitted comments from RL on the SA and the EA. The comments contained in Reference 2 had already been incorporated in the EA that was transmitted by Reference 3. WHC will submit the revised SA by December 23, 1992. Appropriate comments contained in Reference 2 have also been incorporated in the attached SE for

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emergency pumping Tank 241-T-101 using a submersible pump (including the installation of a saltwell screen).

One of the enclosures to Reference 2 was a letter (H. H. Eckert, DOE-HQ, to R. E. Gerton, RL, "Review Comments on the Ferrocyanide Tanks Stabilization Safety Assessment and Environmental Assessment," dated November 18, 1992) which contained a request for an engineering evaluation of alternatives (EEA) to interim stabilization.

WHC recommended against preparation of such an EEA (References 3 and 4) since the alternatives to interim stabilization were addressed in the Hanford Defense Waste Environmental Impact Statement Record of Decision (Federal Register, Volume 53, Number 72, dated April 14, 1988).

On November 19, 1992, WHC requested that Kaiser Engineers Hanford (KEH) coordinate the preparation of such an EEA. WHC has now requested KEH to expedite the preparation of this EEA as an emergency action. However, WHC again requests RL to reconsider this delay in an emergency response to an assumed leaker tank. Preparation of this EEA will cause at least a 50-day delay in the schedule for pumping (Reference 4) Tank 241-T-101 depending on the scope of the EEA, which was not clearly defined in Reference 2.

Submittal of Safety Evaluation for Emergency Pumping of Tank 241-T-101

The attached SE draws upon existing safety analysis documentation, and concludes that the pumping (interim stabilization) of Tank 241-T-101 can be carried out without undue risk to onsite workers or the general public. The hazards involved in emergency pumping of Tank 241-T-101 using a submersible pump and installing a saltwell screen were evaluated and verification was made that these operations involve no more risk than similar activities analyzed in previously submitted safety documentation. Controls to ensure the safety of the process are included in the SE.

Request for Authorization to Emergency Pump Tank 241-T-101

In accordance with the direction in Reference 2, WHC requests authorization to perform in-tank work in preparation for pumping and subsequently interim stabilization of Tank 241-T-101 on an emergency basis, using a submersible pump. This authorization is contingent upon completion of appropriate readiness reviews and all punchlist items.

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If you have any questions or require further information, please contact Mr. J. M. Grigsby on 376-8907, Dr. G. M. Christensen on 376-5104, or Mr. R. E. Raymond on 373-2785.

Sincerely,

Thomas M. Anderson
President

bjb

Attachment

RL - J. H. Anttonen
G. E. Bishop
G. J. Bracken
R. F. Christensen
R. E. Gerton
R. O. Puthoff (w/o attachment)
S. H. Wisness
J. K. Yerxa

BASIS FOR EMERGENCY PUMPING OF TANK 241-T-101 USING A SUBMERSIBLE PUMP

BACKGROUND

Tank 241-T-101 (101-T) has been declared an assumed leaker by the Westinghouse Hanford Company (WHC) and, therefore, preparations have been made to pump the excess liquid from the tank to mitigate the liquid release. The liquid level in Tank 101-T has been showing a downward trend, and alternate methods have been used to verify an apparent drop in liquid level of 2.5 inches since May 1992.

The methods available to perform pumping are those used for interim stabilization of single-shell tanks (SSTs). The safety of interim stabilization activities has been evaluated in various safety analysis documents. Interim stabilization typically removes the liquid that has drained into a salt well using a jet pump. However, since jet pumping rates are slow, WHC recommends that a submersible pump be used in a salt well to remove the liquid more rapidly. Removal of the easily pumpable liquid reduces the driving force behind the leak and minimizes the impact to the environment. Submersible pumping is the preferred method for liquid removal (Wiggins 1992).

Tank 101-T is on the watchlist for ferrocyanide. These tanks were believed to contain greater than 1,000 g-mol (approx. 500 lb) of ferrocyanide waste, and so were declared to involve an Unreviewed Safety Question (USQ) by WHC in October 1990. A USQ requires that the contractor perform, and the U.S. Department of Energy (DOE) authorize, safety analyses for activities that may involve the USQ to ensure safe operations. Several intrusive activities have already been analyzed as described in safety assessments covering ferrocyanide tanks. WHC believes that a new safety assessment is not required for either the installation of pumping equipment or the submersible pumping of Tank 101-T and that the hazards are similar to those covered by the following existing safety assessments for ferrocyanide tanks:

- WHC-SD-WM-SAD-009 *Safety Assessment for Gas Sampling All Ferrocyanide Tanks*

  This includes the authorization to perform waste tank level measurement per: Letter, R. E. Gerton, RL, to President, WHC, "Waste Level Measurement in Tank 241-T-101," 92-TOD-135, dated October 6, 1992.

- WHC-SD-WM-SAD-011 *Safety Assessment for Sludge Weight Sampling, Auger Sampling, and Penetrometer Testing in Tanks that Contain Ferrocyanide Compounds*

- WHC-SD-WM-SAD-013 *Safety Assessment for Push-Mode Sampling in Ferrocyanide Tanks Without Saltcake Crust*

- WHC-SD-WM-SAD-014 *Safety Assessment for Thermocouple Tree Installation and Operation in Nonleaking Ferrocyanide Tanks*

- WHC-SD-WM-SAD-018 *Safety Assessment for Interim Stabilization of Ferrocyanide Tanks* (to DOE for approval).

Although Tank 101-T is on the ferrocyanide watchlist, investigation of the historical records of tank transfers during and after the ferrocyanide campaigns indicate that the tank now does not contain significant amounts of ferrocyanide. The records show that the majority of the ferrocyanide sludge was removed from the tank in 1953, and the tank was filled and sluiced out before the present waste was introduced (Borsheim 1991).

SCOPE

This document evaluates whether the installation of pumping equipment and the proposed substitution of a submersible pump for a jet pump are covered by the existing safety analysis documentation for ferrocyanide tanks. The evaluation includes a review of the equipment and methodology developed for the activity, a correlation to other safety documentation, and application of the questions used to determine if an unreviewed safety question exists relative to the installation of the pumping equipment and the submersible pumping of Tank 101-T.

DESCRIPTION OF THE ACTIVITY

Tank 101-T contains a total of 133,000 gallons of waste. Thirty thousand (30,000) gallons of this is supernate that lies above the settled solids. After the supernate is removed, the volume of drainable liquid remaining in the solids is expected to be less than 13,000 gallons. This is less than the maximum volume of drainable interstitial liquid (50,000 gallons) allowed for interim stabilized tanks. To accomplish pumping, equipment will have to be installed into Tank 101-T, including both a salt well screen and the actual pump itself.

System Information

In general, the process facilities and equipment needed for pumping Tank 101-T are as follows:

1. Single-shell waste storage tank
2. Pump pit, salt well screen, submersible pump assembly
3. Transfer piping and valve pits
4. Doubly contained receiver tank
5. Double-shell waste storage tank
6. Associated instrumentation and controls.

Single-shell Waste Storage Tank

Tanks in T Tank Farm have a nominal capacity of 530,000 gallons. The tanks are constructed of reinforced concrete with a mild steel liner covering the bottom and sidewalls. See Figure 1.

All of the SSTs have been inactive since 1980. Therefore, no waste transfers into the tanks have been made since that time, and none are planned for the future.

Specifically for this safety evaluation, the emphasis will be on Tank 101-T. Tank 101-T is passively ventilated through a riser with a high-efficiency particulate air (HEPA) filtration system.

Temperature readings from thermocouples at various depths in the waste are taken and recorded manually once a week.

In Tank 101-T liquid waste level is measured with a Food Instrument Corporation (FIC) level gauge. The FIC gauge readings are transmitted to an automatic data recording system, or taken and recorded manually.

Pump Pit, Salt Well, and Submersible Pump

The equipment and installations required for submersible pumping a SST are (1) a pump pit, (2) a salt well screen, (3) a submersible pump assembly, (4) flushing assembly, (5) flex-hose jumpers, and (6) associated controls.

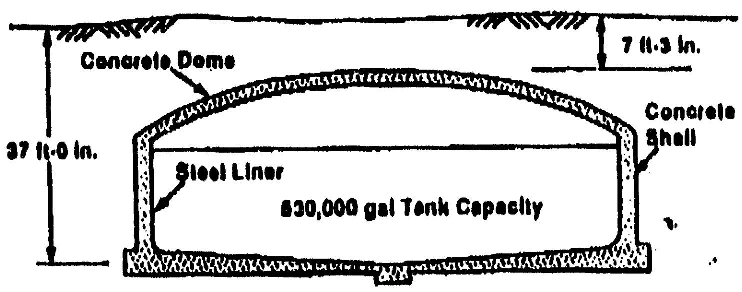
The dome of the SST is built with several risers of different diameters, one of which protrudes into the pump pit. A pump pit is a concrete structure located above the tank dome near the center of the tank. The pumping system is housed within the pump pit with portions of it extending into the riser.

The salt well system is a 10-inch-diameter salt well casing consisting of a stainless steel salt well screen welded to a schedule 40 carbon steel pipe. The casing and screen are to be inserted into the 12-inch tank riser located in the pump pit. The stainless steel screen portion of the system will extend through the tank waste to near the bottom of the tank. The salt well screen portion of the casing is an approximately 10-foot length of 300-series, 10-inch-diameter, stainless steel pipe with screen openings (slots) of 0.050 inch. Because the waste level is at less than 4 feet, the salt well screen will extend above the tank waste. Therefore, the salt well is open to the tank's atmosphere. See Figure 2. The function of the salt well screen is to minimize the size and amount of solids pumped.

The submersible pump is to be mounted to a 2-inch transfer pipe extending up through the tank and the adapter flange to the pump pit. From the adapter flange the waste will be routed through a horizontal discharge flange. From the discharge flange the transfer pipe will then be connected to a flushing tee. The flushing tee is to be connected by flex hose to the connector head attached to the wall nozzle and, finally, to the permanent waste transfer line (SN-6012). See Figure 3.

The submersible pump assembly is needed to raise the liquid from the salt well screen into the pump pit, nominally a 35-foot elevation rise. The submersible pump has a 5-horsepower (hp) motor, driven by 480-volt, three-phase power. The motor itself is below the pump intake and is submersed in the liquid being pumped. The pump is rated at 40 gal/minute at 130 feet total dynamic head, for liquid with a specific gravity of 1.7. The pump motor is cooled by the liquid being pumped, and the minimum specified velocity past the motor is 0.25 foot/second.

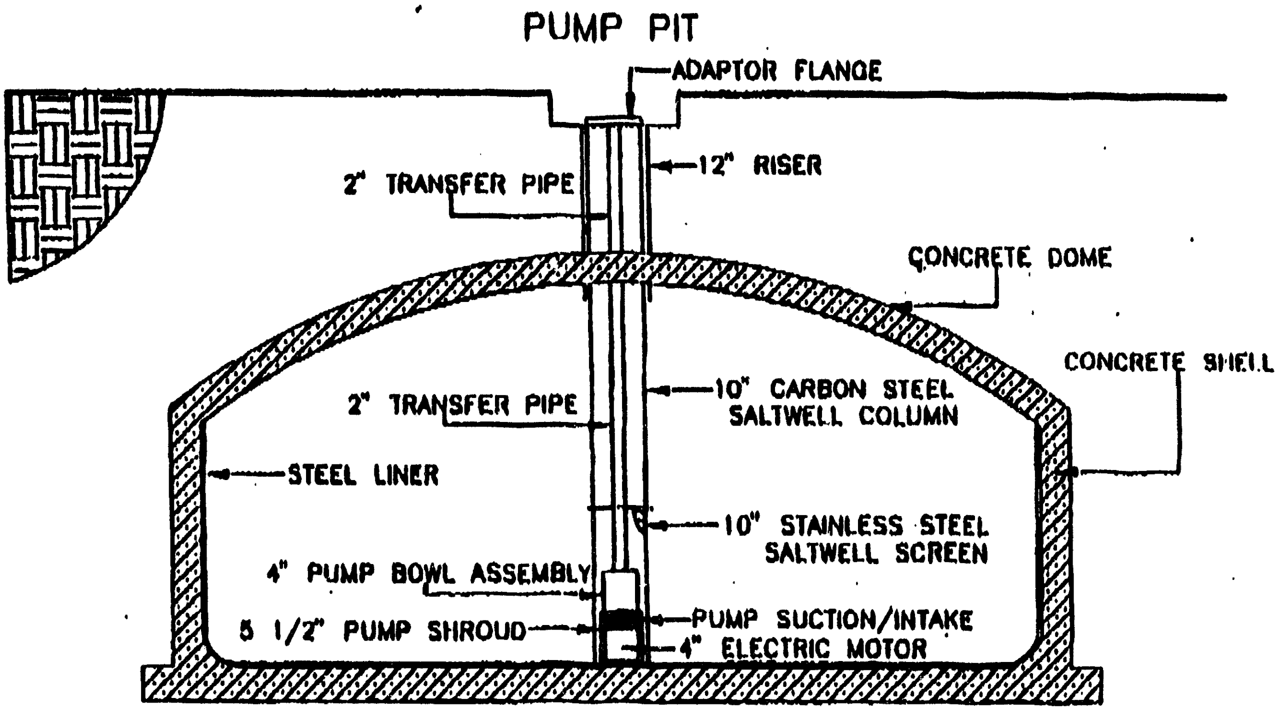
Figure 1 - High-Level Waste Tank Configuration



75 ft Diameter Single-Shell Tank
Tank Farms: BX, T

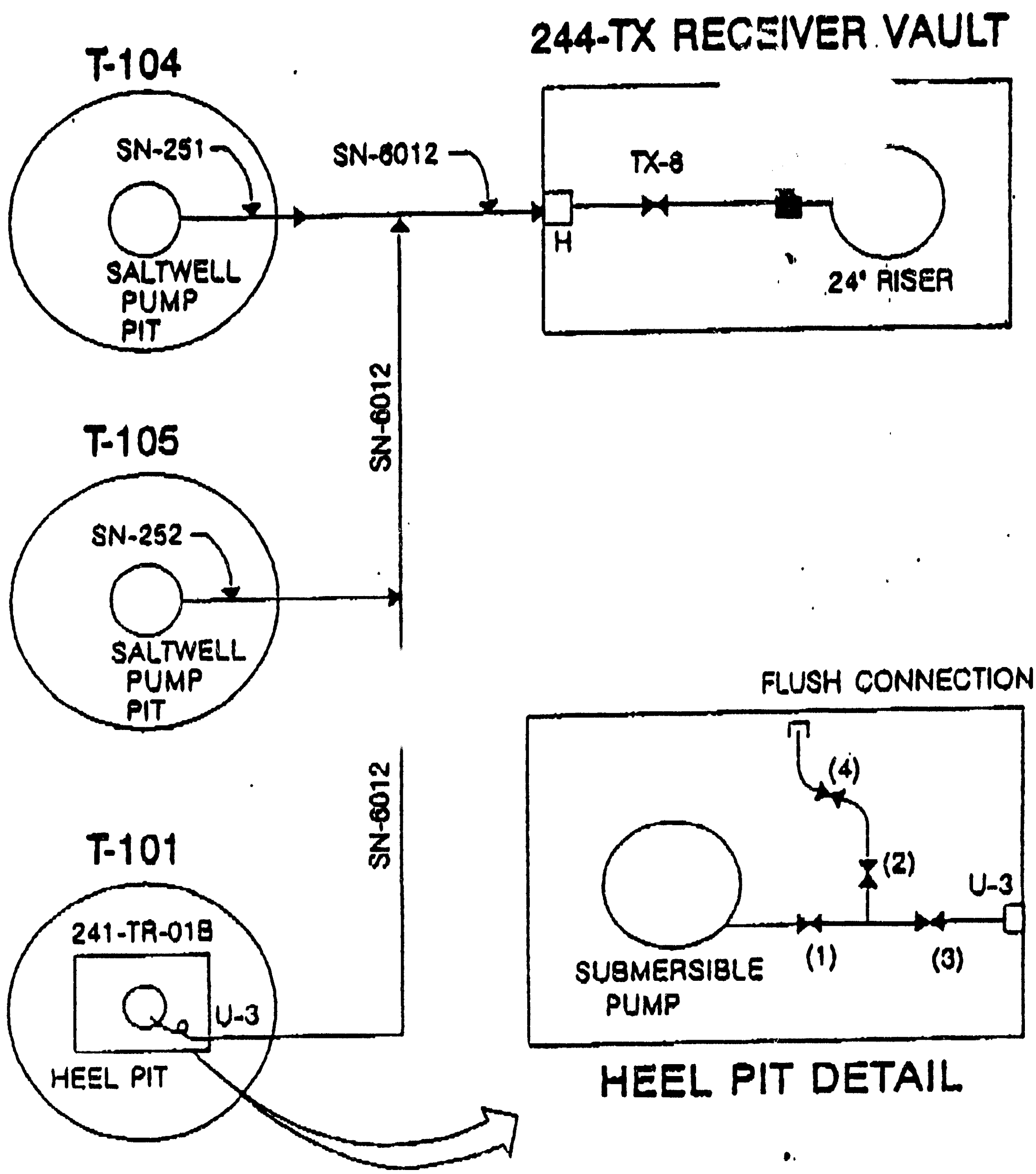
Figure 2 - Single-shell Tank with Pump Pit and Submersible Pumping Assembly

SCALE = NONE



75 FEET DIAMETER SINGLE-SHELL TANK

Figure 3 - Pump (Heel) Pit Detail and Transfer Routing



To aid in the flow past the motor, the pump has a flow director (shroud). See Figure 2.

Important instrument and control systems include (1) leak detection and (2) submersible pump controls, including safety interlocks.

Since the transfer line is a three-pronged manifold system from the 101-T, 104-T, and 105-T pump pits to the joint transfer line (SN-6012) going to the 244-TX DCRT, leak detection is provided in each pump pit, 101-T, 104-T, 105-T, and at the 244-TX DCRT. See Figure 3. The leak detectors are interlocked to shut down the pump in case there is a leak in the transfer piping. A flashing light at the pump pit and an audible alarm at Tank 101-T, located on top of the pump control station outside the pump pit area, alert tank farm operators to the shutdown condition.

An additional interlock associated with the pump itself is a thermal overload device designed to shut off the pump in the event the pump temperature increases from pumping air or stoppage by excessive sludge.

Transfer Piping and Valve Pits

The transfer line (SN-6012) designated to transfer waste from Tank 101-T to the 244-TX DCRT is direct buried with 3 feet of ground cover to provide shielding. The line is carbon steel welded pipe, primarily 2 inches in diameter, with a portion that is 6 inches in diameter. All transfer lines are sloped toward the DCRT for drainage.

The design life of the salt well pumping transfer lines was 5 years. They are now more than 10 years old. Therefore, the lines must be pressure tested before use and every 6 months during use to ensure against leaks. Procedure TO-140-170 describes the method for pressure testing. Pressure testing was analyzed for safety in WHC USQ safety evaluation 10-92-PT-101-T and the DOE notified by letter (Richardson 1992b).

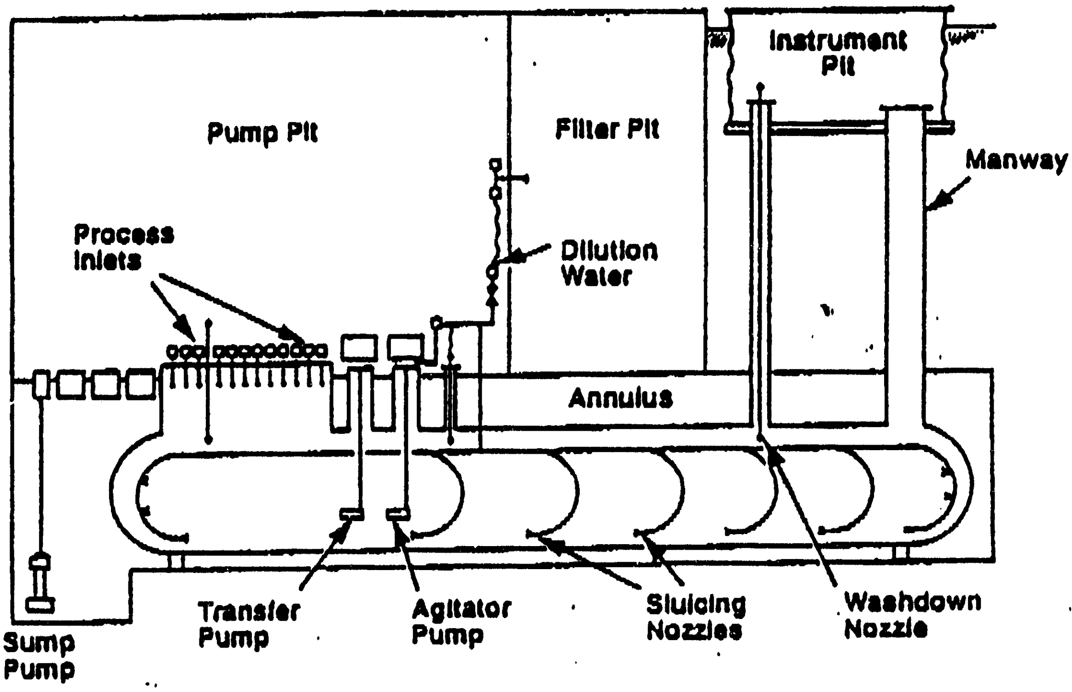
Flow from the tank is routed through the pump pit to the receiving DCRT (244-TX), using Transfer Procedure TO-470-967.

Doubly Contained Receiver Tank (DCRT 244-TX)

The salt well waste from Tank 101-T will go through the 244-TX DCRT. The 244-TX DCRT is a 25,000-gallon cylindrical tank. The tank is positioned with its axis horizontal in the lower section of the reinforced concrete vault. Above the tank vault, and connected to it, are a pump pit and a filter pit. An instrument enclosure is also above the tank vault but not connected to it.

The pump pit contains transfer and agitator pumps and jumper connections to the transfer lines and valves. The filter pit contains a ventilation system equipped with HEPA filters. The tank vault contains the receiver tank and sump well. Associated instrumentation is contained in the instrument pit. See Figure 4.

Figure 4 - Receiver Vessel, Typical Configuration



The ventilation system maintains the receiver vessel and annulus under negative pressure with respect to the atmosphere to prevent the release of radioactive materials in case of a tank breach. Supply air is taken into the tank annulus through a coarse filter and a HEPA filter. The exhaust system pulls air from the annulus intake and the inner tank through a coarse filter and two stages of HEPA filters.

Safety considerations and controls on the ventilation system provide dampers and valves for regulation/isolation, measurement of differential pressure across the filters, continuous radioactive particulate monitoring and record sampling of exhaust air, and continuous flow measurement of exhaust air.

The leak detectors in the DCRT sumps are interlocked with the submersible pump to shutdown in the event of a leak in the DCRT. Leak detectors are also installed in the filter pits or filter housing.

To minimize the sedimentation of solids from liquor in the piping systems, the capability of water dilution is provided in the DCRT. In 244-TX, rotating spray nozzles are installed inside the tank to aid in tank flushing. Also, sluice jets and flow from a pump agitator provide a means to resuspend solids and keep in slurry form.

Double-Shell Waste Storage Tank

The transfer will then continue from the 244-TX DCRT to Tank 241-SY-102 using an existing Double-Shell Tank transfer procedure (TO-430-480), after verification of compatibility by sampling and analyzing samples from both tanks.

SAFETY EVALUATION

The safety issues covered in this safety evaluation are associated with equipment installation, post pumping storage of the ferrocyanide waste, and the pumping operation itself.

HAZARDS ASSOCIATED WITH EQUIPMENT INSTALLATION

Hazards associated with the installation of equipment into a ferrocyanide tank have been analyzed in several previously reviewed safety assessments, including loss of containment because of riser damage, penetration of the tank bottom liner from dropped objects, accidental combustion of vapor space gases, toxic vapor exposure, and water addition. The hazards associated with both the installation of the salt well screen and the submersible pump assembly are similar to the previously analyzed activities, as discussed below.

Hazards associated with equipment removal, such as the withdrawal of radiation sources (i.e., the submersible pump or salt well screen), are not included in this safety evaluation. It is not intended to remove either the salt well screen or the submersible pump at this time. However, work plans are being prepared as a contingency in the event either the salt well screen or the submersible pump fail and need to be removed and replaced. The safety of the removal will be evaluated when the procedures are better defined.

Riser Damage

Damage to the riser could occur if either the salt well screen or the submersible pump were dropped, striking the riser with sufficient force. This is extremely unlikely, because both lifts will be performed as critical lifts. However, if either the salt well screen or the pump were dropped and the riser was damaged, gas and vapor confinement could still be maintained by using a thick "donut" type gasket.

Tank Liner Penetration

The possibility exists of unintentionally dropping either the salt well screen or the submersible pump from ground level while they are being lowered into the tank. Tank bottom liner penetration is a potential hazard. WHC-SD-WM-SAD-014 shows that it would take a relatively sharp object (e.g., a thermocouple tree) weighing several hundred pounds and being dropped several feet to penetrate the 1/4-inch steel bottom liner.

The consequence of penetrating the bottom liner would be leakage to the soil. Consequences were evaluated in WHC-SD-WM-SAD-014 for a thermocouple penetration of the tank bottom liner. It was concluded in WHC-SD-WM-SAD-014 that a leak from the penetration of a ferrocyanide tank would pose no significant risk to offsite or onsite workers, but might add to future cleanup efforts. Analysis of Tank 101-T was included in the above referenced study. It can also be concluded that the consequences of a tank bottom liner penetration are the same regardless of the initiating event; therefore, this conclusion would also apply to a salt well screen or submersible pump tank liner penetration.

To prevent this extremely unlikely but potential accident, the salt well screen and submersible pump lifts shall be treated as critical lifts. This requires additional operator training and rigging inspections as described in WHC-CM-6-4.

Electrostatic or Electrical Sparks

A flammability meter will verify, upon entry, that Tank 101-T has no flammable gases above 20% of the lower flammability limit (meter calibrated with methane). Therefore, electrostatic or electrical sparks in the vapor space will have no adverse effect.

The flammability meter test shall be as described in WHC-SD-WM-SAD-009 using an Industrial Scientific (or equivalent) meter with a grounded wire wrapped in TEFLON tube. This type of meter does not detect Normal Paraffin Hydrocarbon (NPH) effectively (Estey 1992); however, there is no reason to suspect NPH in Tank 101-T, because 101-T is not listed as an organic tank in the monthly WHC surveillance report (Hanlon 1992). Even if NPH were present, the flammability meter reading would not be expected to be off by more than a factor of 2 (Estey 1992). Also, NPH vapor, if present, presents virtually no flammability hazard at ordinary temperatures such as those either outside the tank, inside the tank head space, or in the tank breather filter system (Richardson 1992a).

After non-flammability is confirmed, controls to prevent flammable gas ignition, such as grounding and bonding procedures, are not required. This has been established in WHC-SD-WM-SAD-011.

Toxic Gas Exposure

During the opening of the riser there is a possibility of a release of toxic gases (i.e., ammonia, organic vapors, and nitrous oxide) and combustible gas (i.e., hydrogen, etc). Protective measures as described in WHC-SD-WM-SAD-014 and the controls in this safety evaluation will provide adequate safety measures.

Changes in the Waste from Water Addition

Water addition may be necessary to facilitate salt well screen installation, although it is not expected.

The addition of water to ferrocyanide tanks was considered in WHC-SD-WM-SAD-014. The document looked at increased radiolysis of water, lowering the pH values of the waste, releasing toxic or combustible gases, and the redistribution of ferrocyanide compounds. Based upon the conclusions of that safety assessment, water addition will not result in an increased potential for the release of radioactive or hazardous materials.

HAZARDS ASSOCIATED WITH POST-PUMPING STORAGE OF FERROCYANIDE WASTE

Hazards associated with post stabilization storage of the ferrocyanide waste have been analyzed in WHC-SD-WM-SAD-018, a previously reviewed safety assessment for the interim stabilization of ferrocyanide tanks using a jet pump. The hazards reviewed included ferrocyanide reactions with respect to ferrocyanide/nitrate content, moisture removal, and thermal response. The hazards associated with liquor removal using a submersible pump assembly are similar to those previously analyzed, as discussed below.

Ferrocyanide Reactions

Three conditions must be simultaneously present for a release caused by a ferrocyanide/nitrate explosion to occur. They are as follows.

(1) Ferrocyanide and oxidant must exist in sufficient concentrations to be reactive.

(2) Moisture associated with the ferrocyanide sludge must be insufficient to quench a reaction.

(3) The energy balance of the reactive region must be such that temperatures high enough to initiate a reaction can be reached.

Ferrocyanide/Nitrate Content

Tests on oxidant rich mixtures of ferrocyanide and nitrate/nitrite have placed the onset temperature of an energetic propagating reaction at about 285°C (540°F). Results also show that for mixtures with stoichiometric ferrocyanide/nitrate mixtures (1 mol ferrocyanide:6 mol $NaNO_3$) less than 9 wt% of the total, a propagating reaction will not occur. This is a conservative bound for safe storage.

Because the exact quantities and distribution of the ferrocyanide in the tank are considered uncertain, a factor of safety of 3 is applied to the maximum tank concentrations. The factor of 3 was chosen because it is known that for U Plant campaigns, the ferrocyanide added to the various batches was either 0.0025 mol or 0.005 mol. Allowing for the presence of more or less other precipitates that contribute to the volume of the settled sludge and for variances in the settling characteristics of different batches a factor greater than two was chosen. Therefore, if three times the mass of stoichiometric ferrocyanide/nitrate is less than 9 wt% of the mass of the sludge, the tank is considered safe for storage from the perspective of ferrocyanide reactivity.

After pumping Tank 101-T, the ferrocyanide/nitrate concentration will be <3 wt% and, therefore, safe for storage with respect to ferrocyanide reactivity.

Moisture Removal

The primary effect of pumping the tank will be the removal of water and some small amount of suspended solids. The effect of dewatering the sludge that contains ferrocyanide was examined from the standpoint of the reactivity of the remaining mixture. The results of thermal analysis of waste simulant flowsheet sludges indicate materials containing greater than 15% water by weight will not support a propagating reaction.

Sample analyses of tanks containing ferrocyanide in the TY Tank Farm indicate that the minimum water content of the sludge was about 40 wt% (Grigsby 1992). These analyses were made in 1985, about 2 years after the tanks were interim stabilized by salt well jet pumping. Analysis of waste simulant mixtures confirms that the moisture content of the sludges remains high (>60 wt% for U Plant materials) after compaction by centrifuge to simulate long-term settling (Bachtold 1992).

Because pumping of Tank 101-T involves primarily the removal of supernate, the sludge will remain saturated with liquid and, therefore, will be safe for storage with respect to moisture content prevention of a propagating ferrocyanide reaction.

Thermal Response

The temperature histories of ferrocyanide tanks that have been interim stabilized by salt well jet pumping indicate that significant long-term temperature rises have not occurred as a result of jet pumping (Kimura 1990).

Testing of pure ferrocyanide/oxidant mixtures found the temperature for thermal runaway to be 285°C (540°F). However, previous safety assessments on ferrocyanide tank activities assumed a minimum reaction temperature of 200°C (390°F). This is the temperature at which early testing of stoichiometric ferrocyanide/nitrate mixtures showed some exothermic behavior. For the purposes of the evaluation, the lower temperature will continue to be taken as a bounding temperature for safe waste storage.

The Safety Assessment for Interim Stabilization of Ferrocyanide Tanks assessed the potential for temperature rise in ferrocyanide sludges that lie below significant thicknesses of saltcake in some of the ferrocyanide tanks. This temperature rise was assessed to be possible because of the change in thermal conductance characteristics of the saltcake after moisture is removed by jet pumping. Because Tank 101-T has no saltcake, this mechanism for a potential temperature rise in the sludge is not present. There is expected to be no change in the thermal characteristics of the tank and therefore no temperature rise after pumping. It is concluded that the likelihood of achieving temperatures above 200°C (390°F) initiating an energetic ferrocyanide reaction is extremely low and, therefore, pumping Tank 101-T is considered safe.

In summary, the conditions after stabilization of Tank 101-T would be (1) the ferrocyanide/nitrate concentration will be <3 wt%, (2) the sludge will remain fully saturated with liquid with at least 40 wt% moisture, and (3) a temperature rise above 200°C is not possible. Therefore, Tank 101-T falls within the established criteria and can be considered safe for pumping. (WHC-SD-WM-SAD-018)

HAZARDS ASSOCIATED WITH PUMPING OPERATIONS

Hazards associated with pumping operations have been analyzed in previously reviewed safety assessments, including a break of the waste confinement piping or equipment, resulting in a liquid spray, equipment fires in a SST or DCRT, hydrogen accumulation in DCRTs, waste stability following mistransfers, and nuclear criticality. The hazards associated with pumping using a submersible pump are similar to those previously analyzed, as discussed below. Also discussed below is the issue of submersible pump failure, which is specific to this safety evaluation.

Spray Leaks

Previous safety analyses have been done for the interim stabilization of nonwatchlist SSTs. The specific event analyzed was a spray leak from a breached jumper connector in a DCRT pump pit. The most significant factor contributing to potential consequences from the leak was determined to be the possibility of the breach occurring while a cover block was not in place. The frequency of this event was evaluated as 0.011 event/year for the 244-TX DCRT.

The maximum dose consequences for a spray leak while the cover block was not in place were found for the U Tank Farm. The consequence was 13.0 rem effective dose equivalent (EDE) to the onsite individual and 5.4×10^{-02} rem EDE from inhalation offsite. The onsite and offsite dose were reduced to

The source term for the dose consequence analysis was based on the radionuclide content of the pumped liquor. The values used for the analysis of the U Tank Farm are greater than those determined for the supernate samples from any of nonstabilized ferrocyanide tanks. Therefore, the risk analysis for a spray leak event during pumping of Tank 101-T is bounded by the existing analysis performed to evaluate this event for nonwatchlist SSTs. (WHC-SD-WM-SAD-018)

The addition of the submersible pump to the pumping assembly is also bounded by the existing analysis for a spray leak. The consequences for a spray leak are bounded by the results from the interim stabilization of nonwatchlist SSTs, taking into account the short duration of pumping and the amount to be transferred. Both studies require that the coverblocks be in place along the transfer route to mitigate the potential spray leak and reduce the potential consequences to insignificant.

Equipment Fire

Event tree analyses demonstrated that conditions resulting from equipment fires were bounded by existing safety analyses for both watchlist ferrocyanide and nonwatchlist SSTs. The existing safety analyses bound both risk and consequences. Examination of other fire related events in SSTs and DCRTs lead to the conclusion that none are credible. (WHC-SD-WM-SAD-018)

The addition of a submersible pump to the pumping assembly does not change either the likelihood or consequence of an equipment fire.

Hydrogen Accumulation in DCRTs

The evaluated frequency of a fire or explosion because of hydrogen accumulation in a DCRT was the same, 0.34 event/year, for all DCRTs considered in the safety study for interim stabilization of nonwatchlist SSTs. Therefore, it is not expected to be any different for tanks considered in the safety assessment for interim stabilization of ferrocyanide tanks.

In the study for interim stabilizing nonwatchlist SSTs the dose consequences from a hydrogen explosion in the 244-TX DCRT were 0.23 rem EDE onsite and 3.3×10^{-04} rem EDE offsite.

The source term was determined by the hydrogen generation rate and the concentration of radionuclides in the material released from the tank. The consequences of a hydrogen explosion in a DCRT for any of the ferrocyanide tanks analyzed in the interim stabilization study for ferrocyanide tanks are expected to be lower than those calculated for the stabilization of nonwatchlist SSTs because the radionuclide content of the pumped liquor is lower. Therefore, the risk for a hydrogen explosion during pumping of Tank 101-T is bounded by the existing safety analyses. (WHC-SD-WM-SAD-018)

The addition of a submersible pump to the pumping assembly does not change either the likelihood or consequence of hydrogen accumulation in the 244-TX DCRT.

Waste Stability

The safety study for stabilization of nonwatchlist SSTs concluded that there is no increase of risk or any dose consequences expected as a result of inadvertent addition of pumped liquor to a tank because of mistransfer or drainback during pumping. The same is expected to be true for the ferrocyanide tanks because no appreciable ferrocyanide is present in the liquor. (WHC-SD-WM-SAD-018)

The addition of the submersible pump to the pumping assembly does not change either the likelihood or consequence of inadvertent water addition to the tank due to mistransfer or drainback during pumping.

Waste Transfer Lines Leaks/Breaks

The frequency and consequences of leaks to the ground from transfer line breaks during pumping were calculated for the stabilization of nonwatchlist SSTs.

In the safety study for interim stabilization of nonwatchlist SSTs, the frequency of failure for a transfer line was analyzed and found to be 1.7 event/year for a pipe length of 640 feet. For the transfer line from Tank 101-T to the 244-TX DCRT, the frequency of failure was found to be 2.7×10^{-02} event/transfer for a pipe length of 1800 feet and a transfer time of 48 hours. Therefore, even though the pipe length is much longer for this transfer, the frequency of failure is approximately two orders of magnitude less than the referenced study, because of the limited transfer time. If the leak is assumed to be larger, then the consequences may be more severe. The reference study limited the leak to 10,100 gallons. In this case of study, it is anticipated that the submersible pump will not pump at a average rate higher than 20 gallons per minute. At this pumping rate, it would require over 8 hours to pump the referenced 10,100 gallons leaked. But, because the material balance is calculated hourly, this will limit the potential leak rate to 1200 gallons per hour. Therefore, the transfer from Tank 101-T to the 244-TX DCRT is bounded by the existing analysis for transfer line leaks. For additional information see Appendix A to this safety evaluation.

The addition of the submersible pump to the pumping assembly for Tank 101-T is also bounded by the consequences in the safety study for interim stabilization of nonwatchlist SSTs, because of the short duration of pumping and the amount being transferred. To mitigate or reduce the consequences of the potential transfer line leak, all transfer line leak detectors are to be verified operational and a material balance is calculated and recorded at least hourly to verify that the level in Tank T-101 is dropping and the level in the 244-TX DCRT is rising, corresponding to the amount being transferred.

Nuclear Criticality

An amendment to the Justification for Continued Operations resulting from the Criticality Unreviewed Safety Question has been submitted to the Department of Energy for review and approval. The Criticality Safety Evaluation (CSER) for Tank 101-T, "CSER 92-008: Waste Stabilization for Single Shell Tank 101-T," provides conclusive data to support the pumping of liquid from this tank. The CSER concludes "...that waste in these tanks will remain well subcritical throughout the process of removing the liquids. There is no credible way a critical configuration can be achieved, even if the solids are mixed or otherwise redistributed" (Payne 1992b).

Submersible Pump Failure

Additional analyses performed for the use of a submersible pump were (1) a Failure Study of Transfer from Tank 101-T to Tank 102-SY, including a fault tree analysis of failure of a submersible pump during transfer and (2) heat transfer calculations for the failure of a submersible pump inside a ferrocyanide tank.

Bounding heat transfer calculations were performed for the failure of the submersible pump inside the ferrocyanide tank. Failure was a result of a loss of flow past the pump, which would result in a loss of pump cooling for the running pump. The calculations conservatively modeled heat transfer only in the radial direction and neglected significant transport pathways upward and downward, particularly the heat loss expected to occur as the air in the salt well is heated and rises to mix with the vapor space gases. The minimum time required to reach 200°C (390°F) in the sludge under these conditions was estimated to be 1.5 days as calculated in Appendix B of this safety evaluation. The failure study conclusion was that the probability of this event occurring was 3.0×10^{-08} per transfer. This probability is based on the potential human error failure during the mass balance calculations and the failure of the thermal overload switch to activate, preventing the pump from shutting down. In addition to these controls, the amperes of current drain by the pump are also monitored for a drop of more than 50% which would indicate a loss of pump suction, and this is used as an additional criteria for pump shut down by the operator. Based upon the above, the addition of the submersible pump to the pumping assembly for Tank 101-T did not result in the creation of a new credible accident. See Appendix B for additional information.

Also analyzed was the ability of the pump to ignite flammable gases that might be present in the dome space. Based on the pump specifications, the pump has undergone a megger insulation test. Furthermore, based on the required minimum resistance for the megger test and assuming the wiring connections are performed to the specifications, it is assumed that no sparks are possible from the pump. This is further supplemented by the fact that the motor and pump are submersed in the tank liquids which would conduct any power leakage to the grounded salt well. It is for these reasons that no spark will be able to ignite any flammable gases that might be present in the dome of the tank. See Appendix A for additional information.

Therefore, it can be concluded that the addition of the submersible pump does not contribute to consequences of failure of the transfer system, and that the existing safety analyses are bounding for this event.

D. Will the consequences of a malfunction of equipment important to safety be increased?

Response: NO. The integrity of the tank has already been questioned because of the tank's inability to perform its primary function of containment. The act of pumping the tank will not compromise the integrity of the tank, thus, equipment installation and pumping will not increase the potential consequences of a malfunction of equipment important to safety.

E. Will the possibility of an accident of a different type than any previously evaluated in approved safety analyses be created?

Response: NO. Accidents previously analyzed were: riser damage, tank bottom penetration, combustion of vapor space gases, toxic vapor exposure, water additions, ferrocyanide reactions, a spray leak, equipment fires, hydrogen accumulation in a DCRT, waste stability, waste transfer line leaks/breaks, and nuclear criticality. No accident of a different type is anticipated from equipment installation or transfer of liquid from Tank 101-T, using a submersible pump, that is not bounded by the existing safety analyses.

F. Will the possibility of a malfunction of a different type than any previously evaluated in the approved safety analyses be created?

Response: NO. Addition of the submersible pump to the transfer equipment has been analyzed in this safety evaluation and found to be bounded by the existing safety analyses. Worst case submersible pump failure (running with no flow resulting in a waste temperature rise) was analyzed for this safety evaluation and the probability was found to be 3.0×10^{-08} per transfer. This probability is categorized as an incredible event. Therefore, the addition of the submersible pump to the pumping assembly is bounded by the existing approved safety analyses. In addition, controls will be in place to limit the amount of water added to the tank and the temperature of the jetting water is limited to ensure no adverse impact.

G. Will the margin of safety as defined in the basis for any technical specification or safety analysis report be reduced?

Response: NO. The basis of safety in the ferrocyanide waste is a combination of concentrations of ferrocyanide (fuel), sodium nitrate (oxidant), and diluents (especially water). Physical changes that could affect the margin of safety would have to affect the waste temperature and/or significant distribution of the waste. The existing safety analyses have concluded that the likelihood of achieving temperatures high enough to initiate an energetic ferrocyanide reaction is extremely low, even given the optimum ferrocyanide, oxidant, and moisture content.

The possibility of waste heatup due to a pump failure was analyzed for this safety evaluation. The resulting waste temperature after 1.5 days of the submersible pump running without cooling was found to be to 200°C (390°F), the minimum temperature of concern of ferrocyanide sludge. The probability of

REVIEW

A. Will the probability of an accident previously evaluated in the approved safety analyses be increased?

Response: NO. Probabilities for failures during pumping have been analyzed in existing safety analyses. For this safety evaluation, failure of the transfer system including a submersible pump was analyzed and found not to increase the probability of failure. The accidents previously analyzed for interim stabilization of ferrocyanide tanks are bounding due to the short duration of the pumping required and the amount to be transferred for this pumping operation. In addition, the probability of an accident occurring during equipment installation has also been analyzed, and it was found to be incredible. Water addition during equipment installation was also evaluated and found to be within the existing approved safety analyses. Therefore, the probabilities associated with the task of pumping Tank 101-T are bounded by the existing approved safety analyses.

B. Will the consequences of an accident previously evaluated in the approved safety analyses be increased?

Response: NO. The consequences of failure because of pumping have been analyzed in existing safety analyses. The addition of the submersible pump to the pumping assembly was analyzed and found not to increase the consequences above those previously analyzed. The accidents previously analyzed for interim stabilization of ferrocyanide tanks are bounding because of the short duration of the pumping required and the amount to be transferred for this pumping operation. In addition, the consequences of an accident occurring during equipment installation have also been analyzed and found to be within the envelope of the approved safety analyses. Water addition during equipment installation will not result on an increased potential for the release of radioactive or hazardous materials, and, therefore, water addition was found to be bounded by the existing approved safety analyses. Therefore, the potential consequences associated with the task of pumping Tank 101-T are within the envelope of the existing approved safety analyses.

C. Will the probability of a malfunction of equipment important to safety be increased?

Response: NO. The only equipment important to safety in the ferrocyanide tanks is the equipment directly related to the integrity of the tank (safety class 1). The act of pumping the tank will have no effect on the integrity of the tank, thus, it will not increase the probability of malfunction of equipment important to safety. Actions have also been taken to minimize the probability of tank liner penetration during equipment installation. Both the salt well screen and the submersible pump lifts have been classified as "critical" lifts, requiring additional operator training and rigging inspections. Also, the limited water addition will not adversely effect the integrity of the tank, based upon the conclusions of existing approved safety analyses. Any changes in the pH of the waste will be localized and will not effect the tank liner.

this event occurring was also calculated and found to be 3.0×10^{-08} per transfer. This probability is based on the potential human error failure during the mass balance calculations and the failure of the thermal overload switch to activate, preventing pump from shutting down. Based upon this verification, the margin of safety has not been reduced by the addition of the submersible pump to the pumping assembly for Tank 101-T.

CONCLUSIONS

1. Potential accidents and consequences for pumping Tank 101-T are bounded by the existing approved safety analyses as described in this safety evaluation. Therefore, both equipment installation for and pumping of Tank 101-T are covered by existing safety analyses.

2. Appropriate controls are available and indicated below for equipment installation for and pumping of Tank 101-T.

CONTROLS

1. Before opening the pump pit or any riser, combustible gas shall be measured at the HEPA exhaust. After the bolts holding the riser flange are loosened enough to take a gas sample from the riser, but before complete removal of the riser cover, another gas sample shall be taken in the tank vapor space below the riser. This shall be done with an Industrial Scientific Model MX241 or MX251 (or equivalent) flammability meter calibrated on a methane standard. If the combustible gas level is greater than 20% of the lower flammability limit (LFL) at any of the three locations, pump installations activities shall not proceed.

2. Before equipment installation into the ferrocyanide tank, the tank vapor space gases shall have been sampled and analyzed to determine toxic and flammable constituents. Standard Tank Farm methodology shall be used as defined by the Industrial Hygiene and Safety Organization.

3. The salt well screen and submersible pump lifts shall be treated as critical lifts. This requires additional operator training and rigging inspections per WHC-CM-6-4.

4. Personnel breaking confinement shall be on supplied fresh air. Personnel within 28 feet of an open riser or other release point shall be supplied fresh air (Payne 1992a). Respiratory protection for other personnel in the tank farm will be as specified by the Industrial Hygiene and Safety Organization.

5. Contamination control shall be provided around the open pump pit or open riser. The means of contamination control shall be specified in the applicable work package.

6. Ensure that the DCRT ventilation systems are operational and operated at normal flow rates.

7. Ensure that all coverblocks are in place on all facilities (including SST pump pits, valve pits, and DCRTs) before initiating pumping and that no cover blocks are removed until pumping through the affected facility is shut down. Ensure that coverblocks are properly reinstalled after maintenance activities before pumping is resumed.

8. Ensure that all leak detectors along the transfer route are operational prior to transferring waste from Tank 101-T to the 244-TX DCRT.

9. Material balance is to be calculated at least hourly to verify the flow from Tank 101-T to the 244-TX DCRT.

10. The amperes of current drawn by the pump are to be monitored for a drop of more than 50%, which would indicate a loss of pump suction.

11. The equipment installation and operation procedures (along with this safety evaluation) shall be reviewed by Radiation Protection and Industrial Safety personnel.

12. Water addition will be limited to 500 gallons. Jetting water temperature shall be <100°C (<212°F) to minimize water additions and chemical alterations of the waste. Limits on maximum water temperature are imposed because extremely hot water may cause adverse chemical reactions and personnel injury.

The controls and operating conditions discussed in this section must be addressed in the procedures, work packages, training and other appropriate documentation, and observed in conducting work. Preparation for interim stabilization of a ferrocyanide tank shall include a review of this safety evaluation and other applicable safety documentation to ensure the continued validity of the analysis in light of an increased understanding of the tank's contents and of changes in the equipment and process.

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Tank Farm Safety Analysis

APPROVED BY:

DATE 11/24/92
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Tank Farm Safety Analysis

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Section 4.5

Justification for Continued Operations to Support Stabilization Activities in 241-T-101

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ATTACHMENT
Page 1 of 9

JUSTIFICATION FOR CONTINUED OPERATION

OF HANFORD

HIGH-LEVEL WASTE TANKS

Background

The issue of criticality safety in Hanford Tank Farms was declared an Unreviewed Safety Question (USQ) on April 30, 1992. This USQ was declared because the existing Safety Analysis Reports (SARs) for the Single Shell, Double Shell, and Aging Waste Tanks state that a criticality is not credible. This conclusion may not be technically defensible for the full range of postulated tank constituent conditions. Questions regarding fissile material inventory and spatial distribution raise concerns that cannot be confirmed to be within the approved safety envelope defined in the current SAR. Therefore, in conjunction with the U.S. Department of Energy, Richland Field Office (RL) and U.S. Department of Energy, Headquarters (HQ), the contractor, as required by DOE 5480.21, 10.b (3), performed a safety evaluation and the resultant determination was that a USQ existed for criticality safety in High-Level Waste (HLW) Tanks.

The criticality USQ is a Priority 2 Waste Tank Safety Issue at the Hanford Site, on the basis that it affects only some of the necessary conditions that could lead to an uncontrolled release of radioactive waste (under extreme assumptions). As a Priority 2 Safety Issue, the prohibitions of the Wyden Amendment, which are only applicable to Priority 1 Safety Issues, do not apply.

The primary mission of the Tank Farms, to provide predictable waste storage capacity for generating facilities, can not be interrupted for an extended time without serious consequences.

Allowed Operations

This Justification for Continued Operation (JCO) identifies the following operations: (A) those operations which do not affect nuclear reactivity, and, therefore, do not affect criticality safety within the tank; (B) those operations which have negligible impact on nuclear reactivity, and, therefore, have negligible impact on criticality safety within the tank; and, (C) those operations which require further evaluation, and, as such, are placed on administrative hold until the evaluation data is submitted to, and approved by, RL.

Basis

The allowed operations set forth in this JCO can be conducted safely, even though most of the Hanford HLW Tanks contain more than the minimum critical mass of fissile material under optimum conditions within the waste.

For Plutonium (Pu) bearing waste to go critical, three conditions must occur. First, there must be sufficient mass; second, there must be sufficient concentration; and third, the shape must be favorable. For the waste composition in the Tank Farms tanks, a criticality will not occur if the fissile material concentration is controlled to less than 3 grams per liter of solids. This is because the total mass of fissile material is distributed throughout the waste in a concentration less than that required for a criticality for any mass under any conditions of moderation or reflection (Reference SD-SQA-CSA-20108, "CSAR 79-007 Underground Waste Storage Tanks and Associated Equipment").

Hanford has rigorously controlled the fissile material concentrations and alkalinity in the Double-Shell Tanks (DST)s. The analytical results from core samples indicate the fissile material concentrations are at least an order of magnitude lower than the minimum critical concentration of 3 gram/liter. Additionally, the DST inventory tracking system records fissile material inventories in all DSTs at significantly below the total mass allowed by the Criticality Prevention Specification (CPS), even after conservative adjustments were made to account for measurement and sampling uncertainties.

The analysis of core samples taken from some of the Single Shell Tanks (SSTs) indicate a fissile material concentration of less than 0.20 grams per liter. The inactive status of the SSTs ensure that no additional fissile material will be discharged to these tanks.

Finally, sample results from DSTs show that the alkaline supernatant is non-transuranic (i.e.,- less than 100 nCi/gram), which means that any alkaline liquid transfers to the tanks will not result in additional precipitation of fissile material beyond that already contained in the transferring liquid. Dilute (i.e., much less than 3 grams per liter alkaline fissile solution) liquid additions per assumptions contained in Criticality Safety Evaluations (CSERs), should actually decrease the effective multiplication factor, and provide a negative effect on nuclear reactivity.

These facts provide reasonable assurance that a nuclear criticality within the tanks is remote, and, further, that the operations specified in this JCO can be performed with negligible or no impact to criticality safety.

ALLOWED OPERATIONS

A. This section lists those HLW Tank operations which do not affect nuclear reactivity within the tanks:

Allowed Operation #1

Westinghouse Hanford Company (WHC) may perform tank farm surveillance activities in the dome space outside of the waste, such as liquid level monitoring, liquid observation well scans, temperature readings, dome surveys, dry well scans, tank vapor space monitoring, and installation and repair of monitoring equipment.

Justification

These activities do not affect nuclear reactivity because no movement of fissionable material occurs, and, therefore, mass and distribution of fissile material is not affected. These activities are required to ensure compliance with Operational Safety Requirements (OSRs), Operating Specifications Documents (OSDs), and to resolve Waste Tank safety issues.

Allowed Operation #2

For tank farm operations not affecting nuclear reactivity, and not listed above, WHC shall submit to RL a concise justification for the proposed operation. This justification shall be reviewed, approved, and attached as an amendment to this JCO prior to conduct of the proposed operation.

Justification

This RL review will independently verify that nuclear reactivity is not affected by an activity not anticipated during the preparation of Allowed Operation #1.

B. This section lists those HLW Tank operations which have negligible impact on nuclear reactivity in the tanks, and, therefore, have negligible impact on criticality safety in the tanks:

Allowed Operation #3

WHC may operate and flush tank airlift circulators located in AZ, AY, and AW Tank Farms.

Justification

These operations have no impact on fissile mass and negligible impact on fissile distribution. Any accumulations or redistribution of fissile material that could have occurred, has already occurred; no other redistribution mechanism exists within the tank. Additionally, the fissile material inventory of these aforementioned tanks is well below the criticality prevention specification limit of 50 kilograms. Finally, the fissile material inventory in 101-AZ has been confirmed by core sample analytical data to be 16.8 kilograms plutonium versus an engineering estimate of 9.5 kilograms.

These airlift circulators have operated safely for many years within a conservative safety envelope. Continued operation of these airlift circulators in the AZ Tank Farms is required by current OSRs to maintain a safe heat distribution within the "aging waste" tanks.

Allowed Operation #4

WHC may perform tank contents sampling operations (push mode or rotary mode core sampling, auger, and supernatant, including bottle-on-a-string) in the waste tanks.

Justification

Nuclear reactivity is not appreciably impacted by sampling operations because the sample volume is so minute with comparison to the tank volume. For example, each core sample is one inch in diameter and consists of 244.5 ml/segment. Other sampling devices approximate the same volume of material displaced. In addition, these activities are necessary to ensure compliance with existing OSRs, OSDs, Part B Permit Applications, and to support the overall waste characterization program.

Allowed Operation #5

WHC may install monitoring equipment (e.g.-thermocouple trees) using the water lance method. This method involves additions of no more than 1500 gallons of non-fissile bearing liquid through a pipe for safe installation.

Justification

Reasonable and conservative assumptions and sample results factored into analyses contained in CSERs demonstrate that the documented tanks affected are likely to be overmoderated. Given these analyses, non-fissile liquid additions will actually decrease the effective multiplication factor and thus decrease the nuclear reactivity within the tank (Reference: WHC-SD-SQA-CSA-20108, "Underground Waste Storage Tanks and Associated Equipment", page 3). The H/Pu ratio at 40 percent water (60 percent sludge) is far too large for low plutonium density waste to be critical (H/Pu equals 10,615 for one gram of plutonium per liter). The maximum H/Pu for a critical system is about 3600 and the optimum H/Pu ratio (maximum k-infinity) is in the 100 to 1000 range. In reducing the water content to obtain this range, the sludge density must increase. This requires water contents of less than ten percent in most cases. It is extremely unlikely that this low a water content could be obtained except on a hot plate. Installation of this monitoring equipment is necessary to provide data for heat transfer modeling.

Allowed Operation #6

WHC may conduct operations involving aqueous additions to assist with temperature control and conduct operations involving the addition or transfer of non fissile aqueous solutions into waste tanks. This may be done to perform instrument flushes, pump catch tanks, enter pits, maintain liquid levels, conduct evaporator mini-run and operations, and conduct routine maintenance.

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Justification

Tanks affected by these operations, as described in Operation #5, are thought to be overmoderated based on analyses contained in the CSER. Addition of non-fissile aqueous solutions, per these analyses, should decrease the effective multiplication factor, and decrease the nuclear reactivity in the tank. Operational history has shown that the return water from pump pits and catch tanks is primarily non-fissile, contaminated water which does not affect the fissile material content, and therefore, does not increase the nuclear reactivity in the tanks. Aqueous additions are necessary to ensure the safety of work performed in the tank farm. Evaporator operations are evaluated in WHC-SD-SQA-CSA-20112, "CSAR 81-022, Waste Evaporators 242-A, 242-S" and state "With the maximum concentration of fissile material in the feed solution limited to 0.01 grams per gallon, we conclude there is no criticality potential and the evaporators meet the safety requirements...".

Allowed Operation #7

WHC may conduct 101-SY Window Activities for the same basis cited in Allowed Operation #5. These activities are called-out separately because of their visibility and importance to waste tank safety programs. Operations such as removal of the sludge weight (including addition of water for flushing), air lance removal, pump pit entry to support photography (including addition of water for contamination control) and Multifunctional Instrument Tree (MIT) installation have negligible impact on the mass or distribution of the fissionable material; on the nuclear reactivity within the tanks; and, therefore, on criticality safety.

Hydrogen mitigation activities may potentially impact the distribution of fissionable material and are not included in Allowed Operation #7. These hydrogen mitigation operations have been separately evaluated and will be approved per Section C.2.

Justification

See Allowed Operation #5.

Allowed Operation #8

WHC may transfer new liquid waste from generators (e.g. analytical laboratories, Plutonium Finishing Plant, Purex) to "Non-Watch List" DSTs with total fissile inventories established within their respective CPS.

Justification

These operations will be authorized by WHC only after the following administrative controls/checks and balances have been performed to assure a safe envelope of operations:

- An auditable record of transfers and continuous inventory will be maintained by WHC. The incremental addition of new liquid wastes, complying with the technically defensible CPS, will be in the form of very low concentration solutions and will provide negligible nuclear reactivity to the already subcritical DSTs.

- A fissionable inventory of the DSTs to which the wastes are proposed to be transferred will be established, with bounding estimates which take cognizance of inaccuracies in analytical results and inconsistencies between analytical results, DST Tracking records, or other historical data. The upper bound of the fissionable inventory thus obtained, will be used for purposes of determining whether any given operation of this kind can be allowed. The estimation technique and methodology will be documented in sufficient detail to be technically defensible and to allow for independent review and verification.

- The operational limit for all DSTs, except as allowed below, will be reduced to 25 kg Pu equivalent. The existing CPS limits are based on a maximum Pu concentration of 4 g/l which requires a minimum of 250 kg Pu for criticality. A tank operating mass limit an order of magnitude less than the minimum critical mass will be used in place of the Criticality Prevention Specification (CPS) limit while operating under this JCO.

- Tanks containing more than 25 kg Pu equivalent fissile material (except 102-SY) are restricted from receiving newly generated waste under this JCO. Tank 102-SY, with a Pu equivalent inventory above 42 kg is a special case and is addressed under Allowed Operation #10.

- The maximum concentration of fissile material entering the tanks shall not exceed 0.05 grams of Pu equivalent per gallon of waste.

- Approval for transfers containing <u>less</u> than 15 grams of fissile material will be allowed only after confirmation of the fissile material inventory of the waste batch is performed by the Operations Shift Manager. Systems Engineering will review each transfer on a case-by-case basis to ensure compliance with the CPS.

- Approval for transfers containing greater than 15 grams of fissile material will require documented justification and approval from the Criticality Safety Representative (CSR) and Waste Tank Safety Assurance, (WHC General Transfer Procedure, TO-025-001). This represents an additional layer of scrutiny to ensure safe operations with respect to criticality safety.

Allowed Operation #9

WHC may perform waste transfers within tank farms (i.e.- inter-tank transfers); however, these transfers will be limited to non-"Wyden Amendment" DSTs. Inter-DST tank transfers are subject to the same administrative controls described in Allowed Operation #8. SST activities are placed on hold per the restrictions described in Section C.

Justification

Both core sample analysis and historical records review will establish defensible fissile inventory values for DSTs involved in inter-tank transfers. Core sample analysis from DSTs show that fissile concentrations are at least an order of magnitude below the one gram/liter limit allowed by the CPS. Inter-tank transfers will also be subject to the same administrative controls/checks and balances described for transfers of newly generated waste in Allowed Operation #8. Inter-tank transfers will not involve SSTs. SST operations affecting nuclear reactivity are "on hold" per the discussion in Section C.

Allowed Operation #10

WHC may transfer liquid wastes to Tank 102-SY. This operation is called-out separately because of its vital importance to the stabilization and clean out of material in the Plutonium Finishing Plant (PFP). No means of moving new liquid waste from PFP exists except by transfer to 102-SY using existing piping systems.

WHC may transfer to 102-SY from sources other than PFP, provided the solution being transferred is within the specifications for PFP transfers. For example, the 222-S Laboratory and T-Plant, the primary sources of HLW tank analysis, may discharge waste to 102-SY.

Justification

The fissile material inventory in 102-SY was previously reported as 37.1 kilograms and 0.14 grams per liter in the solids, according to the DST tracking system. The inventory was recently revised to 42 kilograms and 0.16 gram per liter based on core sample analysis. This is well within the CPS limit of 125 kilograms and 2 grams per liter in the solids.

Although the concern about the redistribution of fissile material by air lift circulators (ALCs) has been raised, and 102-SY does have ALCs, those ALCs have not been used in the tank since the mid-1980's and they are currently locked out; no other redistribution mechanism exists within the tank.

Fissile material entering 102-SY is discharged by the PFP, which specifically adds iron (a neutron "poison" and a diluent for controlling the concentration of fissile material within the sludge) to the waste to control nuclear reactivity and to ensure compliance with the Tank Farm CPS (Reference: OSD-Z-184-00010).

The following controls and limits apply to all transfers into 102-SY.

- The fissile material concentration entering 102-SY will not exceed 0.05 grams Pu equivalent per gallon of waste mix (solids and solutions).

- The waste mix entering 102-SY will contain solids of no less than 0.6 percent by volume.

- The fissile concentration in the solids will be less than 2 grams Pu equivalent per liter.

- Iron hydroxide (or equivalent neutron absorber) at a concentration of at least 35 grams of iron per liter of solids will be coprecipitated with the fissile material. Iron hydroxide is added to PFP waste as a diluent and a neutron poison.

- All waste material will be sampled, with independent verification of results, for compliance with the above controls and limits prior to transfer to 102-SY.

C. This section lists operations that may affect nuclear reactivity; these operations are not listed in Sections A or B because they require further evaluation. As such, these operations are placed on administrative hold until further conclusive data relative to criticality safety impact is available:

1. Single Shell Tank Stabilization - pumping of liquid waste from SSTs to accomplish SST Stabilization requires additional evaluation. The evaluation shall address the removal of supernatant moderator and, if necessary, establish appropriate administrative and operational controls to minimize risk and ensure the safety of these operations.

2. Other intrusive operations (e.g. 101-SY mitigation activities such as mixer pump installation, Hydrogen mitigation activities, SST retrieval activities, etc.) performed in HLW Tanks that may affect nuclear reactivity must be evaluated for impact and approved by RL and/or HQ prior to performing the operation.

At such time as further conclusive data becomes available to support additional operations, the proposed operation and its supporting data will be referenced at the end of the JCO, but the entire data package should not be included. Similarly, the JCO should be cross referenced in the documentation for the operation. Conditions specified under the allowed operations in this JCO must still be satisfied until issues associated with the USQ are addressed. This data must support the position that the proposed operation will provide no or negligible effect to nuclear reactivity in the tank. The package will be submitted to RL and/or HQ for review and approval prior to conduct of the operation.

AMENDMENT 1:

1. Single Shell Tank stabilization of 101-T is evaluated in CSER 92-008. This tank is inactive and has not received waste since before 1981 and will not receive any more process waste, furthermore the tank is suspected of leaking. Pumping the tank will reduce the environmental impact, however the CSER only addresses removing the liquid regardless of the method. Removal of liquid reduces the degree of neutron moderation from a highly overmoderated state to a state of lower moderation. It is concluded that the waste will remain well subcritical throughout the process of removing the liquids. There is no credible way for a critical configuration to be achieved, even if the solids are mixed or otherwise redistributed. Criticality is precluded by the low enrichment of the fissile isotopes in the heavy metals. Due to their physical and chemical similarities, the Pu is expected to remain well mixed with the uranium. Nevertheless, even if the Pu is assumed separated from the uranium, the concentration would still be so low that no scenario can be constructed which might credibly lead to criticality.

   Waste from tank 101-T will be sampled in 244-TX and a destination will be determined from that analysis. From past analysis of 101-T tank waste, tank 102-SY will be the probable destination. If the waste is transferred to tank 102-SY all requirements in AO #10 of this JCO will be met.

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Section 4.6

Internal Memos Supporting Stabilization of 241-T-101

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Westinghouse Hanford Company | **Internal Memo**

From: Single-Shell Tanks
Phone: 3-1321 R1-49
Date: March 10, 1993
Subject: TANK 241-T-101 WASTE COMPATIBILITY ASSESSMENT

To: S. D. Godfrey R1-51

cc:			
A. T. Alstad	R1-49	M. N. Islam	R3-08
D. B. Bechtold	T6-09	J. R. Jewett	T6-09
D. C. Board	S1-57	M. E. Lakes	R1-51
V. C. Boyles	R1-49	T. E. Rainey	R1-49
R. A. Dodd	R1-51	R. E. Raymond	R1-80
G. T. Dukelow	R2-32	L. Ruffin	R1-51
G. L. Dunford	R1-51	J. S. Schofield	R1-51
R. K. Fuller	T6-30	J. D. Thomson	R1-30
T. W. Halverson	R2-50	D. D. Wiggins	R1-49
D. G. Hamrick	R1-51	MJS/KGC:VCB File/LB	

References:

(1) Document, Operating Specifications for the Saltwell Receiver Vessels, WHC OSD-T-151-00011, Rev. C-1, dated December 3, 1991.

(2) Document, Tank Farm Waste Compatibility Program, WHC-SD-WM-OCD-015, Rev. 0, dated November 1, 1991.

(3) Internal Memo, R. L. Weiss to D. J. Saueressig, "Analysis of Liquid Samples from Tank 241-SY-102 Taken June 2, 1989," 12712-PCL89-149 Rev.1, dated August 29, 1989.

(4) Internal Memo, D. R. Bratzel to A. J. DiLiberto, "Interim Results of Tank T-101 and T-107 Analysis and T-101/Neutralized Plutonium Finishing Plant Acid Waste," 12712-PCL89-144, dated August 1, 1989.

(5) Document, Safety Analysis Report for Saltwell Receiver Facilities, WHC-SD-WM-SAR-032, dated March 21, 1989.

Recommendations

Based on currently available waste characterization data for wastes stored in tanks 241-SY-102 and 241-T-101 (Reference 3 and Table 3, respectively), emergency pumping Tank 241-T-101 to the 244-TX Double Contained Receiver Tank (DCRT) can begin with respect to compatibility of the wastes to be mixed.

However, Systems Engineering recommends sampling and characterizing the waste in Tank 241-SY-102 to confirm the waste compatibility results prior to pumping the waste into Tank 241-SY-102. The risks of beginning pumping to the 244-TX DCRT are believed minimal because any new characterization data for Tank 241-SY-102 are expected to be similar to those of Reference 3. Tank 241-SY-102 waste was very dilute in June 1989 when it was sampled and only similar waste has been added since then.

Furthermore, Systems Engineering recommends holding and agitating the Tank 241-T-101 waste in the 244-TX DCRT for up to 30 days followed by sampling and characterizing the aqueous phase for transuranic species. The purpose of this operation is to verify the laboratory scale mixing test results of Reference 4. The assumptions are that the urgency of transferring the waste on to Tank 241-SY-102 will be reduced once Tank 241-T-101 is pumped, and that a cautious approach can be accommodated. However, it is understood that this verification activity is contingent on enough space being available in 244-TX for the Tank 241-T-101 waste and on maintaining continuity of Plutonium Finishing Plant operations.

Conclusions

Tank 241-SY-102 is designated as the receiver tank for emergency pumping Tank 241-T-101 based on an initial waste compatibility assessment using existing waste characterization data. Table 1 summarizes the results of the assessment and gives a disposition of two compatibility issues identified in the comparison of waste characterization data with the waste compatibility criteria.

The chemical composition of Tank 241-SY-102 supernate needs updating prior to pumping the Tank 241-T-101 waste to the SY Tank Farm receiver tank. The most current characterization data available for the Tank 241-SY-102 waste is from supernate samples taken in June 1989.

A chemical adjustment of the Tank 241-T-101 waste will have to be made for receipt into the 244-TX DCRT in order to comply with Tank Farm Operating Specifications (OSDs) and Operational Safety Requirements (OSRs) for waste composition (References 1 and 5).

Background

Tank 241-T-101, one of the 530,000 gallon single-shell tanks constructed in 1943-1944, was declared an assumed leaker on October 4, 1992. A total of approximately 30,000 gallons of pumpable liquid is stored in the tank. Since October, an emergency pumping campaign has been in progress. Because the tank was declared a ferrocyanide Watch List tank in 1990 in accordance with Public Law 101-510, Section 3137, additional safety studies had to be completed before pumping could begin. Approval for initiating emergency pumping actions was received from the U.S. Department of Energy-Headquarters on February 25, 1993. One of the required actions involved sampling and characterizing the Tank 241-T-101 liquid waste to provide data for completing a waste compatibility study prior to pumping. This memorandum provides the results of that waste compatibility study.

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Discussion

Waste Characterization

On March 4, 1993, three 100 mL supernate samples were retrieved from Tank 241-T-101 using the sample bottle-on-a-string method. The sample locations and identifications are listed below (note that the sample locations are levels in the supernate which is approximately 12 inches deep):

Sample Location	Customer ID	Lab ID
Top Sample	101-T-SURF	R-2846
Middle Sample	101-T-WAST	R-2847
Bottom Sample	101-T-BOIL	R-2926

The samples were sent to 222-S laboratory for analytical and physical analysis. A summary of the Tank 241-T-101 supernate chemical composition is given by Table 2 and is based on the raw analytical data listed in Table 3. Additionally, a 135 mL composite sample (using 45 mL from each original sample) was created to perform a bench scale boildown experiment by Process Chemistry.

Table 4 provides an average composition of the Tank 241-SY-102 supernate based on the characterization data reported in Reference 3. Note that a number of the chemical, radionuclide, and physical property determinations required by the tank farm waste compatibility program of Reference 2 are missing. Specifically, the values of three key constituents, i.e., hydroxide ion (OH^-), carbonate (total inorganic carbon), and total organic carbon (TOC), are important for performing the waste compatibility assessment. Because of the dilute nature of the waste, the total inorganic carbon (TIC) and TOC values were set at zero for this initial waste compatibility evaluation. An OH^- concentration was estimated at 0.5 moles/L ($\underline{M}$) by setting its value such that the charges between the anions and cations balance.

Samples from Tank 241-SY-102 will be needed to fully characterize the waste and confirm the initial compatibility assessment performed using the currently available analysis. Since the last sampling in June 1989, roughly 215K gallons of additional waste has been added to the tank. This increase in waste volume is not expected to change the waste composition appreciably because major plant operations have not been generating high salt waste. Consequently, any new Tank 241-SY-102 characterization data are expected to confirm the initial compatibility results documented by this memorandum.

Compatibility Assessment

The initial waste compatibility assessment of the Tank 241-T-101 waste was conducted following the process described in the tank farm waste compatibility program document (Reference 2). The process includes characterizing the wastes involved in the proposed operations, comparing waste compositions against the compatibility criteria, identifying concerns, and resolving compatibility issues.

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The initial compatibility assessment of the Tank 241-T-101 waste is summarized in Table 1. Two compatibility concerns were identified when the wastes were compared to the criteria. The first concern arises from the general criteria (Section 5.1.1 of Reference 2) and relates to existing requirements for waste composition limits that have been established to control corrosion. The specific technical criterion (Section 5.2.2 of Reference 2) that deals with categorizing wastes as complexed (CPLX) if the TOC exceeds 10 grams/L when concentrated to double-shell slurry feed (DSSF) was identified as the second concern. As noted in Table 1, all other compatibility criteria applied to the waste were in compliance.

The identified compatibility concerns and their resolution are discussed below:

Section 5.1.1 - The Tank 241-T-101 waste OH^- concentration does not comply with the tank farm OSD and OSR for the 244-TX DCRT (References 1 and 5). The requirements on waste composition provide corrosion control in the facility waste tank and transfer lines.

Resolution: OH^- adjustments will be made in the 244-TX DCRT as appropriate such that the waste in the facility will meet the waste composition limits of the OSD and OSR.

Section 5.2.2 - Given the composition of Tank 241-T-101 waste in Table 2, simulation of the evaporator process using the PREDICT code gives a TOC value of 27 grams/L at the DSSF composition. This TOC is above the 10 grams/L specified in the compatibility criterion for categorizing waste as CPLX. Tank 241-SY-102 contains dilute non-complexed supernate and a transuranic (TRU) sludge. Wastes that are categorized as CPLX are segregated from both non-complexed wastes and TRU wastes.

Resolution: A laboratory study was performed to study the behavior of the Tank 241-T-101 waste during evaporation to reduce the volume. Because organic analyses methods are not yet available for Hanford tank waste matrices, determination of organic complexants in the waste are not possible for verifying that wastes are CPLX. A bench scale boildown of a waste provides a qualitative measure of whether a waste high in organic content exhibits CPLX waste behavior. Producing a highly viscous, non-settling slurry when evaporating to the point of solids nucleation is a manifestation of the CPLX waste behavior.

A boildown of a Tank 241-T-101 waste composite produced a slurry that 1) precipitated solids roughly when expected, 2) concentrated after the initial solids precipitation, and 3) separated to form a settled solid layer and a supernate upon standing. These are characteristic of non-complexed waste behavior. After four days of settling, the sample bottle for the boildown concentrate contained roughly 25 vol% settled solids and 75 vol% supernate. Based on the laboratory boildown, the Tank 241-T-101 waste is categorized as non-complexed waste and can be transferred to Tank 241-SY-102.

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Summary

No additional waste categories or tank safety risks will be created as a result of transferring liquid waste from Tank 241-T-101 to Tank 241-SY-102.

If you have any questions, contact either Kelly Carothers at 3-4556, or Mike Sutey at 3-2408.

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Single-Shell Tanks

K. G. Carothers, Principal Engineer
Systems Engineering

Concurrence:

M. N. Islam, Manager
Waste Tank Safety Assurance

D. C. Board, Manager
TWRS Quality Engineering

lmt

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TABLE 1

T-101 Waste Compatibility Compliance Table

Criteria	Waste Compatibility Program Requirements WHC-SD-WM-OCD-015	T-101 Compliance Status	Disposition
5.1.1	Comply with requirements of all applicable documents (i.e., OSD, SAR/OSR, CPS, etc.)	Chemical composition doesn't meet requirements of OSD-T-151-00011 and OSR 11.3.1 of WHC-SD-SAR-032.	OH and NO_2 chemical adjustment will be made in 244-TX DCRT
5.1.2	Wastes contained in Watch List for DST shall be isolated.	Not applicable. Tank T-101 is not a DST and Tank SY-102 is not a Watch List Tank.	In Compliance
5.1.3	New waste streams generated by chemical process require an approved Tank Farm flowsheet.	Not Applicable. Waste not a new waste source and not generated by a process facility.	In Compliance.
5.2.1	Organic complexants (i.e., EDTA) as major constituent must be segregated as complex (CPLX).	Organic complexants not the major constituents.	In Compliance.
5.2.2	Concentrated wastes w/TOC of > 10g/L must be segregated as CPLX.	Initial results indicate 27 g/L TOC at the DSSF composition.	Out of Compliance. Lab experiment required to categorize waste.
5.2.3	Wastes that contain > 3 wt% TOC on a dry basis shall be segregated as CPLX.	Highest calculated value at 0.26 wt% TOC.	In Compliance.
5.2.4	Wastes that contact TRU solids layers must not dissolve the TRU constituents.	Solubility test with PFP TRU solids performed (See Internal Memo 12712-PCL89-144, D. B. Bratzel to A. J. DiLiberto, August 1, 1989).	In Compliance.
5.2.5	High phosphate waste ($[PO_4]>0.1M$) not to be mixed with high salt waste.	Waste not a high phosphate waste. Average PO_4 concentration = 0.04 M.	In Compliance.
5.2.6	Wastes that exhibit exothermic reactions at < 232°C shall be segregated.	DSC recorded at 400°C exhibited no exotherms	In Compliance.
5.2.7	Wastes that exhibit energy releases from exotherms in excess of endotherms shall be segregated.	DSC recorded at 500°C exhibited no exotherm.	In Compliance.

TABLE 2

SUMMARY
TANK 241-T-101 SAMPLE RESULTS

	R-2846 Surface Sample *(Molarity)*	R-2847 Middle Sample *(Molarity)*	R-2926 Bottom Sample *(Molarity)*	AVG *(Molarity)*
NaOH	0.16	0.16	0.15	0.16
$NaAlO_2$	0.02	0.03	0.02	0.02
$NaNO_3$	2.63	2.60	2.59	2.61
$NaNO_2$	0.61	0.61	0.63	0.62
Na_2CO_3	0.42	0.41	0.42	0.41
Na_2SO_4	0.09	0.10	0.10	0.10
Na_3PO_4	0.04	0.04	0.04	0.04
NaCl	0.03	0.02	0.02	0.02
NaF	0.05	0.05	0.05	0.05
TOC	0.90 g/L	0.72 g/L	0.69 g/L	0.77 g/L
SpG	1.21	1.22	1.21	1.22
$\%H_2O$	71.14	71.14	71.09	71.12

TABLE 3
TANK 241-T-101 SUPERNATANT
LIQUID SAMPLE COMPOSITION

DETER.	R 2846	R 2847	R 2926	UNITS
OH LIQ	2.69E 03	2.65E 03	2.62E 03	μG/ML
NO3	2.63E 00	2.60E 00	2.59E 00	M
NO2	2.79E 04	2.79E 04	2.88E 04	μG/ML
PO4	3.80E-02	4.11E-02	4.22E-02	M
SO4	9.38999E-02	9.67E-02	1.01E-01	M
Cl	2.50E-02	2.48E-02	2.46E-02	M
F	5.28E-02	5.18E-02	5.28E-02	M
TIC	5.03E 03	4.86E 03	4.98E 03	μG/ML
TOC	8.97E 02	7.15E 02	6.88E 02	μG/ML
NH4	1.47E-03	4.20E 01	3.40E 01	μG/ML
CN LIQ	6.58E 00	6.87E 00	9.00E 00	μG/ML
SPG	1.2147E 00	1.2167E 00	1.2147	G/ML
% SOLIDS	2.856E 01	2.862E 01	2.89E 01	WT%
DSC	NO EXOTHERM	NO EXOTHERM	NO EXOTHERM	
TGA	7.144E 01	7.138E 01	7.109E 01	% H_2O
pH	1.293E 01	1.281E 01	1.281E 01	
TB	1.02E 02	1.06E 02	1.04E 02	μCi/ML
AT	3.40E-02	4.02E-02	3.44E-02	μCi/ML
GEA (Cs137)	7.06E 01	7.02E 01	6.70E 01	μCI/ML
Sr90	1.28E-01	8.70E 00	4.39E 00	μCi/ML
Pu239/40	2.74E-04	4.75E-4	3.16E-04	μCi/ML
Am241	3.57E-05	1.03E-04	6.99E-05	μCi/ML
Np237	< 3.14E-05	< 2.60E-05	< 4.58E-05	μCi/ML
U	2.79E 00	4.63E 00	3.90E 00	μG/ML
Al	4.15E 02	8.48E 02	4.62E 02	μG/ML
Ag	1.81E 00	2.15E 00	1.86E 00	μG/ML
B	3.01E 01	1.83E 01	2.94E 01	μG/ML
Ba	2.20E-01	1.31E 01	1.87E 00	μG/ML
Bi			1.23E 02	μG/ML
Ca	1.31E 01	3.99E 01	2.07E 01	μG/ML
Cr	1.91E 03	1.91E 03	1.86E 03	μG/ML
Cu		2.63E-01		μG/ML
Eu	4.38E-01	4.95E-01	4.53E-01	μG/ML
Fe	3.95E 00	3.89E 02	5.60E 01	μG/ML
K	7.09E 02	7.20E 02	7.17E 02	μG/ML
La	1.93E 00	1.67E 02	2.59E 01	μG/ML
Mg	7.05E-01	7.45E 00	1.46E 00	μG/ML
Mn	1.31E 00	1.87E 02	2.67E 01	μG/ML
Mo	2.28E 01	2.25E 01	2.24E 01	μG/ML
Na	1.10E 05	1.07E 05	1.07E 05	μG/ML
Ni	1.73E 00	6.28E 00	2.05E 00	μG/ML
P	1.16E 03	1.17E 03	1.12E 03	μG/ML
Pb		9.25E 00		μG/ML
S	3.39E 03	3.30E 03	3.34E 03	μG/ML
Si	1.23E 02	1.69E 02	1.15E 02	μG/ML
Sr		1.20E 01	1.69E 00	μG/ML
Ti		2.60E-01		μG/ML
W	5.27E 01	5.29E 01	5.20E 00	μG/ML
Zn	5.75E-01	1.85E 00	6.08E-01	μG/ML
Zr		1.50E 00		μG/ML

TABLE 4

TANK 241-SY-101 SUPERNATE COMPOSITION

REQUIRED DETERMINATIONS PER WHC-SD-WM-OCD-015	AVERAGE COMPOSITION (REF 3)
OH	
NO_3	3.40E-01 M
NO_2	5.00E-02 M
PO_4	2.50E-03 M
SO_4	< 1.30E-03 M
Cl	4.50E-03 M
F	4.00E-02 M
TIC	
TOC	
NH_4	
CN	
SpG	1.015 G/ML
% SOLIDS	
DSC	
TGA	94.90 WT%
pH	
TB	
AT	1.06E-01 µCi/L
GEA (Cs137)	5.15E 03 µCi/L
U	
Pu239/40	1.02E-01 µCi/L
Am241	6.28E-02 µCi/L
Np237	
Sr90	5.27E-01 µCi/L
Al	4.17E-02 M
Ca	6.00E-05 M
Cr	1.90E-04 M
Fe	
K	8.90E-02 M
Na	9.00E-01 M
P	3.00E-03 M
S	
Si	

Westinghouse Hanford Company | **Internal Memo**

From: Waste Tank Safety Analysis 29120-MK-92156
Phone: 6-2520 H5-32
Date: November 11, 1992
Subject: ANALYSIS OF EXPECTED TEMPERATURE RESPONSE IN TANK T-101 FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

To: N. J. Milliken H5-32

cc: J. M. Grigsby H5-32
R. D. Crowe H5-32
MK File/LB

Attached is a report of the subject analysis.

Maryanne Kummerer

M. Kummerer
Senior Engineer

cab

Attachment

EXPECTED WASTE TEMPERATURE RISE FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

Summary and Conclusions

Calculations were performed to estimate the maximum rate of temperature rise in the waste contents of Tank T-101 should cooling to the submersible pump motor be lost. For simplicity of calculation, it was assumed that heat from the pump was transported only in the radial direction, through the saltwell and into the waste. The effects of heat loss from the system in the upward direction were neglected.

The waste was assumed to be ferrocyanide sludge. The minimum waste temperature of concern was taken to be about 200 °C. The heat generation rate from the uncooled motor was taken to be 2000 watts. The calculated time for the temperature in the waste to reach 200 °C was about 1.5 days.

To reach this result required that the pump motor achieve unrealistically high temperatures (about 950 °C). Damage to the motor would prevent power being supplied to it well before this temperature is reached. Heat leaving the system by upward flow of heated air through the saltwell, and by conduction from the waste surface into the tank vapor space, would further mitigate the temperature rise. Therefore, it is concluded that, if the pump were to continue running for a time without cooling flow, an increase of the temperatures in the tank contents to a hazardous level is not expected.

Method of Calculation

The assumed geometry was a series of three concentric cylinders with the inner cylinder representing the pump, the middle cylinder representing the air gap between the pump and the saltwell wall, and the outer cylinder representing the tank contents. The heat output of the pump was estimated to be 2000 watts. This value was based on the specified minimum flow (0.25 ft/s) required to cool the pump during normal operations. Test information needed to calculate the pump heat was obtained from the vendor of the motor (Franklin Electric). The pump heat was calculated using the equation for surface convection:

$$q = hA(T_m - T_f)$$

Where:
- q = heat generation rate (watts)
- h = the heat transfer coefficient (W/m^2 °C)
- A = the wetted surface of the motor (0.19 m^2)
- T_m = test temperature of the motor shell (38°C)
- T_f = temperature of the test fluid (water at 19°C)

EXPECTED WASTE TEMPERATURE RISE FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

The heat transfer coefficient, h, was calculated using the relation for turbulent flow of water in annular spaces given in Marks, 1951:

$$h=160(1+0.012t_f)\frac{V^{0.8}}{D^{0.2}}$$

Where:
- t_f = fluid temperature (65.6 °F)
- V = fluid linear velocity (0.25 ft/s)
- D = annular clearance in inches between the motor and shroud (1 inch)

This gave a value for h of about 94 BTU/hr ft^2 °F (535 W/m^2 °C). Using this value in the convection equation yields a waste heat value for the motor of 1930 watts. This was rounded to 2000 watts for the purpose of the calculations.

Solution for the transient temperatures at radial distances from the pump were calculated using the TRUMP (Edwards, 1972) computer code. The code uses a finite difference method to solve the heat balance equation for a variety of geometries. A one dimensional, cylindrical geometry was used for this case. This is analogous to modeling the case as an infinitely long cylinder with heat flow in the radial direction only. The dimensions and physical parameters used in the model are discussed below:

Heat Source - The heat source of 2000 watts was distributed over the volume of the inner cylinder, with a radius of 2 inches (.05 m) and a 1 meter length. This gave a volumetric heat source of 2.5 x 10^5 W/m^3.

Radial Dimensions - The pump was modeled as steel with a radius of .05 m. The saltwell space, with a radius of .1 m, was given the properties of air. The remainder of the model, to the outer tank radius of 11.4 m, was sludge. The thickness of the steel shroud and the saltwell were interposed between the pump and saltwell space, and the saltwell space and waste, respectively. Interface nodes were used between materials to model the resistance to heat flow expected where materials with diverse thermal conductivities are adjacent to each other.

EXPECTED WASTE TEMPERATURE RISE FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

Thermal Properties - The thermal properties used for the three materials are given in the following table.

Material	Density kg/m^3	Heat Capacity J/kg °C	Thermal Conductivity W/m °C
Steel	8000	500	50
Air	1.3	1006	.18*
Sludge**	1500	3000	2.0

* The thermal conductivity of air at about 300 K is given as .03 W/m °C. This value was multiplied by 6 to simulate the combined effect of conduction and convection through the air gap.

** The density and heat capacity of the sludge are those given in Grigsby, 1992. The thermal conductivity is that obtained from testing of ferrocyanide waste simulants as reported in Meeuwsen, 1992.

Initial and Boundary Conditions - The starting temperature for the whole system was taken to be 68 °F (20.3 °C). This is the maximum temperature for tank 101-T given in Hanlon, May 1992. A constant temperature of 20.3 °C was imposed at the tank outer boundary.

Discussion

The cal_ulated time for the temperatures in the waste near the saltwell to reach 200 °C was about 1.5 days. This is on the order of the time it would take to heat the one foot thickness of sludge adjacent to the saltwell to 200 °C adiabatically with 2000 watts heat input. Therefore, it is considered reasonable.

The simplified treatment for modeling purposes neglected important pathways by which heat would leave the system in the real case. As the temperature of the air in the saltwell rises, the density of the air will decrease. The warmer air will flow upward carrying heat out of the system. Additionally, as the temperature of the sludge rises, some of its heat will be lost by conduction to the vapor space above it. These heat loss mechanisms, if accounted for, would increase the time required to reach sludge temperatures of concern.

EXPECTED WASTE TEMPERATURE RISE FROM LOSS OF COOLING TO THE SUBMERSIBLE PUMP

References

Edwards, A. L., 1972, "TRUMP: A Computer Program for Transient and Steady-State Temperature Distributions in Multidimensional Systems", UCRL-14754, Rev. 3, Lawrence Livermore Laboratory, Livermore, CA.

Franklin Electric, 1988, "Submersible Motors: Application, Installation, Maintenance Manual", Franklin Electric, Bluffton, IN.

Grigsby, J. M., et al, 1992, "Ferrocyanide Waste Tank Hazard Assessment - Interim Report", WHC-SD-WM-RPT-032, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Hanlon, B. M., 1992, "Tank Farm Surveillance and Waste Status Summary Report for May, 1992", WHC-EP_0182-50, Westinghouse Hanford Company, Richland, WA.

Marks, L. S., 1951, Mechanical Engineers' Handbook, Fifth Edition, McGraw-Hill Book Company, Inc., New York.

Meeuwsen, P. V., 1992, "Test Report for Thermal Conductivity of Ferrocyanide Waste Simulants," WHC-SD-WM-TRP-079, Westinghouse Hanford Company, Richland, Washington.

Section 4.7

Miscellaneous Documentation Supporting Stabilization of 241-T-101

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RECORD COPY

OCT 07 1992

SFD:WFH 92-CAB-261

FERROCYANIDE TANKS STABILIZATION SAFETY ASSESSMENT AND ENVIRONMENTAL ASSESSMENT

John C. Tseng, Director
Hanford Program Office
Office of Waste Management
Environmental Restoration
and Waste Management, EM-36/HQ

Reference: Letter, D. C. Richardson, WHC to R. E. Gerton, RL, Complete of Milestone 2024: Complete Safety Assessment for Pumping Ferrocyanide Tanks and Milestone 2001: Submit Recommendations on Interim Stabilization of the TPA, dated September 30, 1992, 9257308.

Enclosed for your review are the subject safety assessment and environmental assessment and the reference recommendation on interim stabilization for ferrocyanide tanks. Copies were given informally to your staff during their trip to the Richland this week and electronic copies were sent to headquarters individuals. Westinghouse Hanford Company (WHC) is addressing the criticality Unreviewed Safety Question (USQ) concern for pumping of Ferrocyanide Tanks in an amendment to the Justification for Continued Operation (JCO). This amendment will require Program Secretarial Office (PSO) approval

We will conduct our review on a priority basis in consideration of the declared 101-T Tank leak, in order to provide WHC written comments no later than Monday October 12, 1992. Please advise us of the schedule on which HQ can perform a review.

If you have any questions, please contact W. F. Hendrickson of my staff on (509) 376-5862.

Sincerely,

ORIGINAL SIGNED BY

R. F. Christensen, Acting Director
Safety Division

Enclosure

RL F 1325.6 (5-87)

United States Government

Department of Energy
Richland Operations Office

memorandum

DATE: JAN 28 1993

REPLY TO ATTN OF: TOD:GEB 93-TOD-010

SUBJECT: SINGLE-SHELL TANK STABILIZATION PROGRAM - RECOMMENDATION

TO: Assistant Secretary
for Environmental Restoration
and Waste Management, EM-1, HQ

Reference: Memorandum; J. C. Tseng, HQ, to J. H. Anttonen, RL, "Tank Waste Remediation System Program Guidance," dated December 29, 1992.

The referenced memorandum requested formal recommendations for the interim stabilization program so that they may be incorporated into the on-going Tank Waste Remediation System (TWRS) rebaselining effort. The SST radioactive waste should be managed in a proactive manner and should minimize the release of radioactive waste to the environment, while maintaining tank safety.

Stabilization of the SST's has been viewed as a proactive means of management in response to anticipated future tank leakage. The SST's are now beyond their design life, and leakage from any of the tanks, including 67 tanks which are assumed to have leaked in the past, may occur at any time. The stabilization program will remove as much of the radioactive liquid as possible, before the tanks begin to leak. The stabilization program does not constitute abandonment of the SSTs.

The enclosure to this memorandum is an issue paper that examines stabilization issues. RL recommends that the remaining forty-four unstabilized SST's be stabilized as soon as safely possible. This position should be the basis for any redefinition of the TWRS baseline.

JAN 28 1993

Assistant Secretary -2-

If you have any questions, please contact me or your staff may contact Mr. Ronald E. Gerton, Acting Program Manager, Office of Tank Waste Storage on (509) 376-9106.

ORIGINAL SIGNED BY

John D. Wagoner
Manager

Enclosure

cc w/encl:
J. C. Tseng, EM-36, HQ
J. E. Lytle, EM-30, HQ
A. R. Griffith, EM-36, HQ

bcc TOD OFF FILE # 1400.1B
TOD RDG FILE
TWS RDG FILE
TWR RDG FILE
SRB RDG FILE I:\CAROL\SSTGEN.007
GEB RDG FILE
MGR RDG FILE

Record Copy Comments: Provides response to Tseng memo requesting guidance on the TWRS base line redefinition. Position taken is consistent with the M-05 change package. Position taken agrees with many of Tseng's positions, but does not allow for modification of the stabilization program until there is definite evidence that stabilization does damage the tank liners. Presents RL's view that release of radioactive waste from the SST's is the issue, and not just release of this in the future. Agrees to perform a corrosion study of the impact of stabilization on corrosion. Should an impact be found, then the stabilization program would be re-evaluated.
Fulfills Commitments: TOD.003, TWS-004, and 930026.0B1/15.

TOD	TOD	TWS	TWR	DEP	MGR
BISHOP	BRACKEN	GERTON	ANTTONEN	HAMRIC	WAGONER
1/25	[illegible]	1/22/93	1/26	1-28-93	1/28

RL

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

FEB 12 1993

92-TWS-006

President
Westinghouse Hanford Company
Richland, Washington

Dear Sir:

INSTALLATION OF SUBMERSIBLE PUMP INTO TANK 241-T-101

This letter authorizes activities planned for installation of the submersible pump in Tank 241-T-101 up to the entrance into the tank dome space confinement. Work may proceed to prepare the installation of the pump into the tank including work within the heel pit, but not within the tank dome space. Authorization to install the submersible pump in the tank should be received from EM-HQ by February 19, 1993. We understand from discussions with your staff that WHC's preparatory work will be completed by approximately February 19, 1993. All activities shall be performed within the bounds of the controls contained in the safety assessment provided by the Westinghouse Hanford Company (WHC) for the installation of the submersible pump into Tank 241-T-101.

The most significant hazard associated with these activities is the radiation exposure to workers. WHC shall ensure that the necessary precautions are taken to keep radiation exposure to an As Low As Reasonably Achievable level and to minimize the potential for spread of contamination.

If you have any questions, please contact Mr. Gary J. Bracken of my staff on 372-1507.

Sincerely,

Ronald E. Garton, Acting Program Manager
Office of Tank Waste Storage

TOD:GEB

cc: H. D. Harmon, WHC
L. L. Humphreys, WHC
M. A. Payne, WHC
T. E. Rainey, WHC
R. E. Raymond, WHC

T101.015

T-101 File

FEB 17 1993

GEB:TOD 93-TOD-024

ADDITIONAL ANALYSIS FOR PUMPING TANK 241-T-101

John C. Tseng, Director
Hanford Program Office
Office of Waste Management
Environmental Restoration and
Waste Management, EM-36, HQ

During discussions held at the Department of Energy, Richland Field Office (RL), on Thursday, February 11, 1993, you requested that RL draft input to a HQ memorandum for selected areas. This input was provided via electronic mail to you and your staff on February 12, 1993.

Your staff subsequently requested a formal submission to you and this is included as enclosure 1.

Minutes of the discussions held at RL on February 11, 1993, will be provided in a separate correspondence.

Approval to pump this tank must be received by RL by close of business, Friday, February 19, 1993, according to the latest schedule supplied by the Westinghouse Hanford Company (WHC), in order to commence pumping the tank by March 15, 1993, as required by Tri-Party Agreement milestone M-05-16. Enclosure 2 is the letter from RL to WHC, dated February 12, 1993, which provides RL direction to WHC to proceed with preparatory work for pumping which can be accomplished prior to HQ approval of pumping. This work will last through approximately February 19, 1993.

John C. Tseng -2- FEB 17 1993

If you have any questions, please contact Mr. Gary J. Bracken of my staff on (509)-372-1507.

ORIGINAL SIGNED BY

Ronald E. Gerton, Acting Deputy Program Manager
Office of Tanks Waste Storage

Enclosure

cc w/encl.
C. O'Dell, EM-36, HQ
H. J. Eckert, EM-36, HQ

bcc: TOD OFF FILE # 1600.9 I:\Carol\T101.018
TOD RDG FILE
TWS RDG FILE
SRB RDG FILE
GEB RDG FILE

Record Copy Comments: Provides formal transmission of the three issues requested to be resolved during discussions held on February 11. Information previously supplied to EM-36. Minutes of the meeting also requested, ~~and to be provided~~ at later date.

OFFICE >	TOD 2/16/93	TOD	TWS			
SURNAME>	BISHOP 2/17	BRACKEN	GERTON			
DATE >	[illegible]	[illegible]	[illegible]			

(Please Return To CAROL SPANHEIMER, R2-62, 2-1507) 12S 21321 RL

Effect of pumping 101-T to 102-SY on possible 102-SY pretreatment in PFP

The radionuclide concentration in the supernatant of 101-T is 93,600 micro-curies per liter of Cs (about 1000 curies Cs) and 50 micro curies per liter of Sr (about 5 curie of Sr). This should be compared to the 4,000 micro curies per liter of Cs in the 600,000 gallons of liquid currently in tank 102-SY (about 9000 curies of Cs). Therefore adding 101-T to 102-SY will result in about a 10% increase in the Curie content in the supernatant and a less than 2% total increase (including the 80,000 curies of Cs and Sr in the sludge) in the total curies content of 102-SY. The chemical content of the supernatant has been evaluated and it will also have no effect on the overall chemical content of tank 102-SY. Therefore, pumping 101-T to 102-SY will not prevent the pretreatment of 102-SY in PFP.

Why pumping of T-101 is considered to be a safe activity:

1. It is very likely that there is little or no FeCN inside this tank. The tank had FeCN added to it in 1953. The tank was then pumped or sluiced to a very low level twice (in 1954 and 1956) which should have removed the FeCN from the tank. Also, the pH measured in the supernatant of this tank (13.3) is high enough that the $Na_2NiFe(CN)_6$ should have solubilized and moved out of this tank (T-101 was the first tank in a cascade series and was cascaded for over 5 years) through the cascade overflow.

2. Even if there is FeCN in the tank, the pumping of the tank will not make the waste less stable. There are two basic arguments in support of this contention: a) the pumping will not remove enough water to significantly change the water content of the sludge and b) the U plant flow sheet material that has been tested to date will not sustain a propogating reaction even if completely dry.

9350449

Mr. R. E. Gerton, Acting Deputy Program Manager
Office of Tank Waste Storage
U.S. Department of Energy
Richland Field Office
Richland, Washington 99352

Dear Mr. Gerton:

TRANSMITTAL OF THE CRITICALITY SAFETY EVALUATION REPORT TO SUPPORT STABILIZATION ACTIVITIES IN 101-T

Reference: Letter, M. A. Payne, WHC, to R. E. Gerton, RL, "Transmittal of Amended Justification for Continued Operations to Support Stabilization Activities in 101-T," 9259447, dated December 29, 1992.

The above referenced letter resubmitted to U.S. Department of Energy, Richland Field Office (RL), for approval, the amended Justification for Continued Operations resulting from the Criticality Unreviewed Safety Question and the desire to emergency pump 241-T-101. The reference also states that the Criticality Safety Evaluation Report (CSER), which provides the justification for pumping 101-T, would be resubmitted later. Attached for your review and approval is the CSER for the specifically identified stabilization activities.

The CSER was rewritten to incorporate comments from U.S. Department of Energy, Headquarters and RL, however the conclusions have not changed. "CSER 92-008: Waste Stabilization for Single-Shell Tank 101-T," provide conclusive data to support the pumping of liquid from this tank. The CSERs conclude "...that waste in these tanks will remain well subcritical throughout the process of removing the liquids. There is no credible way for a critical configuration to be achieved, even if the solids are mixed or otherwise redistributed."

If you have any questions regarding this request, please contact Mr. T. S. Vail (3-2092) or Mr. S. D. Godfrey (3-9126), of my staff.

Very truly yours,

ORIGINAL SIGNED BY

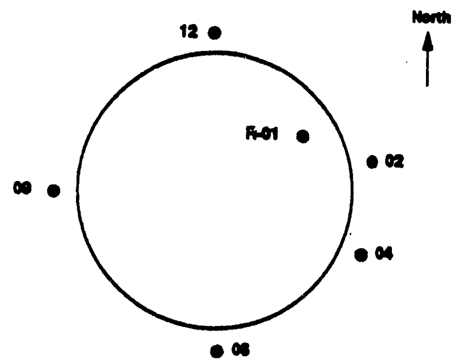
M. A. Payne, Director
Waste Tanks

njm

Attachment

RL - G. J. Bracken J. M. Clark
K. J. Coady R. O. Puthoff
A. D. Toth J. E. Trevino

Tank 241-T-101



Riser and Drywell Locations
Tank 241-T-101

Tank Description

Type: Single Shell
Constructed: 1944
In-service: 12/44
Diameter: 75'
Usable Depth: 16'
Capacity: 530K gallons
Bottom shape: Dish
Hanford Coordinates:
    43,647' North
    75,637' West
Ventilation: Passive

Leak Detection System

Surface Level:
    FIC Riser- R-01
    Manual Tape Riser- None
    LOW Riser(s)- None

Number of External Drywells: 5
Number of Lateral Wells: None

Tank Status

Watch List: ***Ferrocyanide***

Contents

- Type: Non-Complexed Waste
- Total Waste: 133K gallons
- Supernate Volume: 30K gallons
- Drainable Interstitial Liquid: 5K gallons

Isolation Status

- Date Partially Interim Isolated: 12/15/82

Surface Level/Leak Status

- Integrity Category:
- FIC Surface Level: 43.55 Inches (01/01/93)
- Last Photographed: 07/03/84
- Photo Interpretation Comments: See attached photo.

Temperature Status

- Highest temperature during 1992: 76 °F (11/19/92)
- Comments: Temperatures are stable.

Drywell Status

- Comments: Current drywell profiles were stable and consistent with established baseline profiles.

MEETING MINUTES

Subject: TANK 241-T-101 CORRECTIVE ACTION COMMITTEE MEETING

TO: DISTRIBUTION		BUILDING: 2750-E/B103/200 East Area		
FROM: R. E. Raymond		CHAIRMAN: L. L. Humphreys		
Dept-Operation-Component	Area	Shift	Meeting Date	Number Attending
	200E	Day	2/11/93	14

The February 11, 1993 meeting was chaired by R. E. Raymond in the absence of L. L. Humphreys.

CRITICAL PATH ACTIVITIES

- In-Tank Vapor Samples

  Critical path is receipt of DOE-RL/HQ authorization to vapor sample. Authorization was requested on December 23, 1993, but has not yet been received.

- Install T-101 Pumping Systems

  Critical path is DOE-RL/HQ approval to install pump. RL has not received approval from DOE-HQ to install the pump. Installation of the pump is contingent upon RL approval to vapor sample. A day-to-day schedule slip will occur until approval to install the pump is received. In order to meet the T-101 pumping deadline of March 15, 1993, the latest date for approval for pump installation is February 12, 1993.

STATUS OF ACTIVITIES

- Data Management Process Assessment

  - Change request completed and this item is closed out.
  - Updates will be provided to the action committee on a less frequent interval.

- Surveillance Compliance Assessments

  The corrective actions schedule is not complete.

- In-Tank Vapor Sampling

  - Efforts to address DOE concerns are continuing.

  - Readiness review checklists have been reviewed and okayed.

  - To prevent unnecessary delays due to error or oversight, an ESQ review of the work package will be performed again to assure that the work package is correct.

  - The pre-job briefing has postponed until further notice.

- In-Tank Photography

  - Photography dry run of tank 241-T-109 was not performed.

  - In-tank photography is contingent upon the completion of vapor sampling.

- Vadose Zone Investigation

  No status was provided.

- Alternate Level Indication

  - The manual tape is providing daily readings.

  - The FIC repair work package is still on hold. This task being impacted by tank 241-SY-101 Window H activities.

  - A meeting will be scheduled for verification of the scope of the evaluation of alternate level indicating devices. This report has a completion date of March 12 for submittal to the Environmental Protection Agency.

  - The plan for the ultrasonic device is in the approval cycle. The UT device will be required only if 241-T-101 is not pumped.

- Preparation of Pumping Equipment

  - The submersible pump was successfully retested.

  - The readiness review team has begun its meetings. The plan is in work and the checklist has been completed.

Tank 241-T-101 Corrective Action Committee
Meeting Minutes - 2/11/93
Page 3

- Preparation of 244-TX for Transfer

  - A proposed transfer from PFP into 244-TX may potentially create a problem with the T-101 transfer. A determination should be made as to transfer priorities.

- Engineering Evaluation of Alternatives (EEA)

  Internal review comments are due by February 22, 1993. The EEA will be submitted to the Tank Advisory Panel after comments are incorporated.

ITEMS DISTRIBUTED

An attendance sheet was circulated for sign-in purposes and the following items were distributed at the meeting:

- Tank 241-T-101 Action Plan - Rev. 1, Summary Schedule, dated February 10, 1993

- Tank 241-T-101 Action Plan - Rev. 1, dated February 10, 1993

THE NEXT ACTION COMMITTEE MEETING WILL BE HELD ON THURSDAY, FEBRUARY 18, 1993, 9:00 A.M., 2750E/CONFERENCE ROOM B-103/200 EAST AREA.

241-T-101 CORRECTIVE ACTION COMMITTEE

ATTENDANCE SHEET

February 11, 1993

NAME	ORGANIZATION	PHONE	MSIN
S.D. Godfrey	E & P	3-9126	R1-51
VC Boyles	E & P	3-1321	R1-49
D.D. WIGGINS	SST ENGR	3-1286	R1-49
R.J. BLANCHARD	E&P	3-1248	R1-17
J.B. Colson	PNL	5-3785	K5-10
C.E. JENKINS	KEH	6-2145	E6-01
R.R. Stickney	SST Prog.	3-5300	R1-49
C.H. BREVICK	KEH (SUPPORT)	3-4009	R1-30
R.D. House	WHC TWRS	3-3066	R2-83
BE STAPLEY	KEH (SUPPORT)	3-5431	R1-49
LJ Hutton	Scheduling	3-4595	R1-19
GC Dunford	OS	3-1150	R1-51
P. Segall	WHC-Mgmt/PM	3-5037	R2-88
MW HULTGREN	KEH	6-1693	
Richard Guthrie	TFSE	22646	H4-61

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SECTION 5.0

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APPENDIX

DISPOSAL CRITERIA LETTERS FOR TANKS 241-BX-102, 241-BX-106, AND 241-BY-101

OFFICIAL USE ONLY

cc: RE Brown - 2, RE Burns, JP Corley, LW Finch, OF Hill, WP Ingalls, AR Keene, ML Mickelson -, EJ Paas, DW Pearce, T Prudich, ML Short, JM Smith -- 2, MJ Stedwell, HVC - File

March 16, 1955

J. M. Smith, Manager
Radiological Engineering
703 Building, 700 Area

SIXTH TANK OF SCAVENGED TBP SUPERNATE

The supernate in the sixth tank (108-BY-2) of scavenged TBP waste was found not suitable for disposal to ground. Perhaps rescavenging will make it suitable. This tank was filled during the period January 29 through February 16, 1955. It was sampled at three-foot depth increments on February 27, showing the following analytical results:

Height feet	Total β μc/cc	Total γ μc/cc	Sr μc/cc	Cs μc/cc	pH	PO_4^{-3} molarity
Surface (clear like others through 18 feet)						
3	14.5	4.73	2.01	.122	9.4	.137
6	13.3	4.50	2.22	.175	9.4	.140
9	13.5	4.62	1.86	.074	9.4	.190
12	13.4	4.80	1.88	.084	9.4	.193
15	12.6	4.70	1.80	.109	9.5	.202
18	14.3	4.68	1.67	.120	9.4	.200
21.75 (contained sludge, discarded)						
Averages	13.6	4.65	1.90	.114	9.4	.177

Earth Sciences ran a composite of the samples through a soil column, which indicated breakthrough of strontium at about one-half column volume. Because prior experiments with synthetic scavenged TBP supernate showed that higher pH improved strontium adsorption in soil columns, another sample of 108-BY-2 supernate was adjusted to pH 10.9 - 11.0, and the column test was repeated. No improvement was obtained over the original one-half column volume.

A possible clue to the difference between synthetic and actual wastes was found by inspection of column tests on previous actual supernates. Wherever the strontium exceeded 0.6 - 0.7 μc/cc, even though phosphate was good (> 0.1 M), breakthrough column volumes were lower. The 108-BY-2 supernate contained 1.90 μc Sr/cc. (The 107-BY-1 supernate at 1.13 μc Sr/cc was an exception, showing about two column volumes before breakthrough.) Strontium content is one of the factors being investigated which are believed to affect adsorption significantly. Synthetic wastes had been tested up to 1 μc Sr/cc, which optimistically had been hoped was the worst which would be produced. Earth Sciences is beginning tests on two new factors which may be important: ferrous - ferric ion content, and the proposed flowsheet change to oxalate instead of ferrous sulfamate scrub.

Because of the poor soil decontamination of the 108-BY-2 supernate and because the 4300 curies of $strontium^{90}$ contained in it is about as much as the Sr^{90} which has already been discharged to ground from the previous five tanks of supernate, the recommendation of Radiological Engineering is that the present 108-BY-2 supernate not be discharged to the ground. Studies have been started by Separations Technology to determine whether rescavenging or other treatment will make the 108-BY-2 supernate, and other unsatisfactory supernates which may follow, suitable for ground disposal.

H. V. Clukey
RADIOLOGICAL ENGINEERING

HV Clukey:mw

OFFICIAL USE ONLY

July 3, 1956

D. McDonald
Production Planning & Scheduling
Separations Section

DISPOSAL OF 33rd, 34th, 35th, AND 36th TANKS OF THE SCAVENGED WASTE SUPERNATE

Soil tests of the supernates in tanks 33-110-BY, 34-106-BY, 35-107-BY, and 36-108-BY indicated satisfactory adsorption of cesium and strontium. Isotopic analysis of the supernates revealed $cobalt^{60}$ present in concentrations from ten to twenty times the recommended cribbable limit. For this reason it is recommended that disposal to ground of the supernates in the above mentioned tanks be on a specific retention basis, and only as an emergency measure.

W. A. Haney
Radiological Engineering Section

WAH:jt

cc: RE Burns
LW Finch
KR Heid
OF Hill - EL Burley
DW Pearce - JF Honstead
GE Backman
PR McMurray - 2
WAH - file

SEPARATIONS SECTION
ANALYTICAL CONTROL SUB-SECTION
200-W AREA SERVICE LABORATORY

J. J. Courtney

July 19, 1956

TANK SAMPLE

Serial Number	E.P. Code	No.	AT c/m/gal	U #/Gal	Cs uc/gal	Sr uc/gal	3 uc/gal	pH
M 719	36-108 BY	22'			11	$1.3x10^2$		9.7
M 720	36-108 BY	17'			25	$2.0x10^2$		9.7
M 721	36-108 BY	12'			11	$1.6x10^2$		9.7
M 722	36-108 BY	7'			12	$1.5x10^2$		9.7
				PO_4 #/gal				
M 723	36-108 BY							
	(Composite)		$9x10^4$	.076			$5.75x10^4$	

$<$ 1% Solids in any sample (Visual Estimate)

G. H. Winsor
Analytical Control Sub-Section

By J. C. Langford
J. C. Langford

GHW:JCL:rw

cc: KB Heid
RY Lyon
MJ Stedwell
HV Clukey
JF Honstead
ML Sho-t-HP Hisick
JW Jordan
File

SEPARATIONS SECTION
ANALYTICAL CONTROL SUB-SECTION
200-West Area Service Laboratory

J.J. Courtney

July 27, 1956

TANK SAMPLE

Serial Number	E.P. Code	No.	AT c/m/gal	U #/gal	Cs uc/gal	Sr uc/gal	B uc/gal	pH
M 819	39-107 BY	22'			42	37		10.2
M 820	39-107 BY	17'			38	55		9.85
M 821	39-107 BY	12'			82	52		9.85
M 822	39-107 BY	7'			88	59		9.85
					PO_4 #/gal			
M 823	39-107 BY	Composite	$4x10^4$		0.085		$7.12x10^4$	

∠ 1 % Solids (visual) in any sample.

G.H. Winsor
Analytical Control Sub-Section

By J. C. Langford
J.C. Langford

GHW:JCL:eg

cc: RY Lyon
MJ Stedwell
HV Clukey
JF Honstead
ML Short - GE Backman
JW Jordan
File

August 28, 1956

D. McDonald
Production Planning & Scheduling
Separations Section

DISPOSAL OF 37th, 38th, 39th, 40th, 41st TANKS OF THE SCAVENGED WASTE SUPERNATE

Soil tests of the supernates in tanks 37-110-BY, 38-106-BY, 39-107-BY, and 41-110-BY indicated satisfactory adsorption of cesium and strontium. Poor adsorption characteristics were noted for both cesium and strontium present in batch 40-108-BY. Isotopic analysis of the supernates revealed cobalt^{60} present in concentrations from ten to fifty times the reccommended cribbable limit. For this reason it is recommended that disposal to ground of these supernates be on a specific retention basis and only as an emergency measure.

W. A. Haney
Radiological Engineering Section
Radiological Sciences Department

WAH:jt

cc: HE Burns
DW Finch
KR Heid
CF Hill - EL Burley
DW Pearce - JF Honstead
GE Backman
PR McMurrey
WAH - file

DATE
FILMED
5/6/94

END